151815

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EXHIBIT A

1.0 INTRODUCTION

This document is a Remedial Action Plan (hereafter, "Remedial Action Plan", "RAP", "Exhibit A" or the "Document") and describes the work to be performed by the Settling Defendants at the Environmental Conservation and Chemical Corporation ("ECC") Superfund site as required by the attached Consent Decree ("Consent Decree" or "Decree"). This document is attached as Exhibit A to, and is incorporated by reference into and made an enforceable part of, that Decree.

The purpose of this Exhibit A is to set forth those remedial activities to be performed at the ECC site. The Settling Defendants under the Consent Decree ("Settling Defendants") shall arrange to have the work required hereunder performed by a Contractor or Contractors ("Contractor") in accordance with the requirements and specifications set forth herein.

The components of the RAP as presented herein are compatible with the proposed remedy for the adjacent Northside Sanitary Landfill (NSL) site. As the remedial design is finalized for the NSL site, the respective RAPs for ECC and NSL will be reviewed to ensure compatibility of design and construction schedules for each system. If any inconsistencies are identified, the Settling Defendants shall consult with those performing the remedy at NSL, and with EPA and the State to attempt to resolve any such inconsistencies.

2.0 REMEDIAL ACTION PLAN

2.1 Elements of the RAP

2.1.1 Soil Vapor Extraction, Concentration and Destruction

The objective of the soil vapor extraction activity is to remove and destroy VOCs and selected base neutral/acid organics from the soils (as provided herein).

By systematically and uniformly moving air through the zone of contamination, volatilization and hence removal of organics are accelerated. For the ECC site, air movement through the soil will be controlled by a network of vertical trenches installed throughout the zone of contamination. The process also involves the continuous extraction of organics-laden air from the trench system and treatment of the air by activated carbon to remove the organics. The organics so collected will then be destroyed off-site in conformance with applicable Federal and State requirements.

The effectiveness of vapor extraction for organics removal from the ECC soils was demonstrated during a pilot test conducted by Terra Vac, an environmental consulting firm, in June, 1988. The description of the pilot test, including the results obtained, was previously submitted to USEPA and the State of Indiana. The test showed an initial high organics extraction rate of 1.9 pounds per day per foot of trench that decreased over the course of the pilot test to a steady state rate of approximately 0.25 pounds per day per foot of trench. Although the Terra Vac pilot study provides the foundation for the system designed herein for ECC, during the conceptual and preliminary engineering phase, several engineering and operational enhancements were developed which should improve overall performance and effectiveness of the vacuum extraction system to be implemented under this Remedial Action Plan. These system enhancements are the result of consultations among the following environmental consulting firms: ERM-North Central, Inc., Midwest Water Resource, Inc. (MWRI), and Terra Vac, Inc. A summary of the key improvements and the associated measures employed for this enhanced vapor extraction system are as follows:

- Reduction of surface water infiltration within the zone of treatment by construction of the Resource Conservation and Recovery Act (RCRA)-compliant (Subtitle C) cover system;

- Reduction in the volume of air required for effective remediation by reducing air infiltration into the vapor extraction system by constructing the RCRA-compliant (Subtitle C) cover;

- Reduction of atmospheric discharges of treated extraction air by reinjecting the air through a network of injection trenches installed as part of the vapor extraction system;

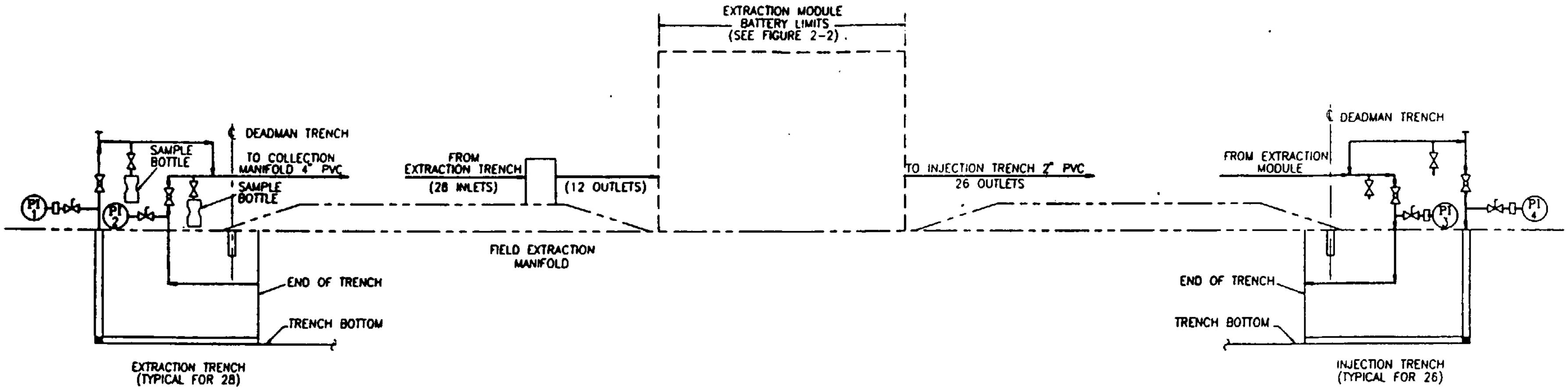
- Positive control (collection and removal) of subsurface* till water encountered in the zone of treatment by providing sufficient vacuum and/or supplemental air to remove water which accumulates in the extraction trenches; and

o Essentially uniform horizontal movement of air through the zone of treatment resulting in enhanced contact between the air and the VOCs in the soil during operation of the soil vapor extraction system by utilizing a network of injection and extraction trenches in conjunction with the impervious cover provided by the RCRA-compliant (Subtitle C) cover system.

* For purposes of this document, "subsurface" water shall mean "ground water", as defined at 40 CFR 260.10.

The following discussion and drawings show concepts and details of the design and operation of the soil vapor extraction system.

The soil vapor extraction process is illustrated in Figures 2-1 and 2-2. The basic operation consists of extraction of air using a single vacuum pump from a network of 28 extraction trenches located throughout the site. Free liquid entrained in the air is removed by gravity in an entrainment separator. Periodically, water which accumulates in the entrainment separator is pumped to an on-site storage tank for subsequent transport to an off-site facility for treatment as necessary, in accordance with applicable Federal, State and local regulations. From the vacuum pump, air passes through the carbon adsorption system, which consists of two upflow carbon columns connected in series. Off-gases from the carbon adsorption system are withdrawn by a pump



SYMBOLS
BALL VALVE (FULLY PORTED)
PRESSURE INDICATOR WITH DIAPHRAGM SEAL & SHUTOFF COCK
GATE VALVE

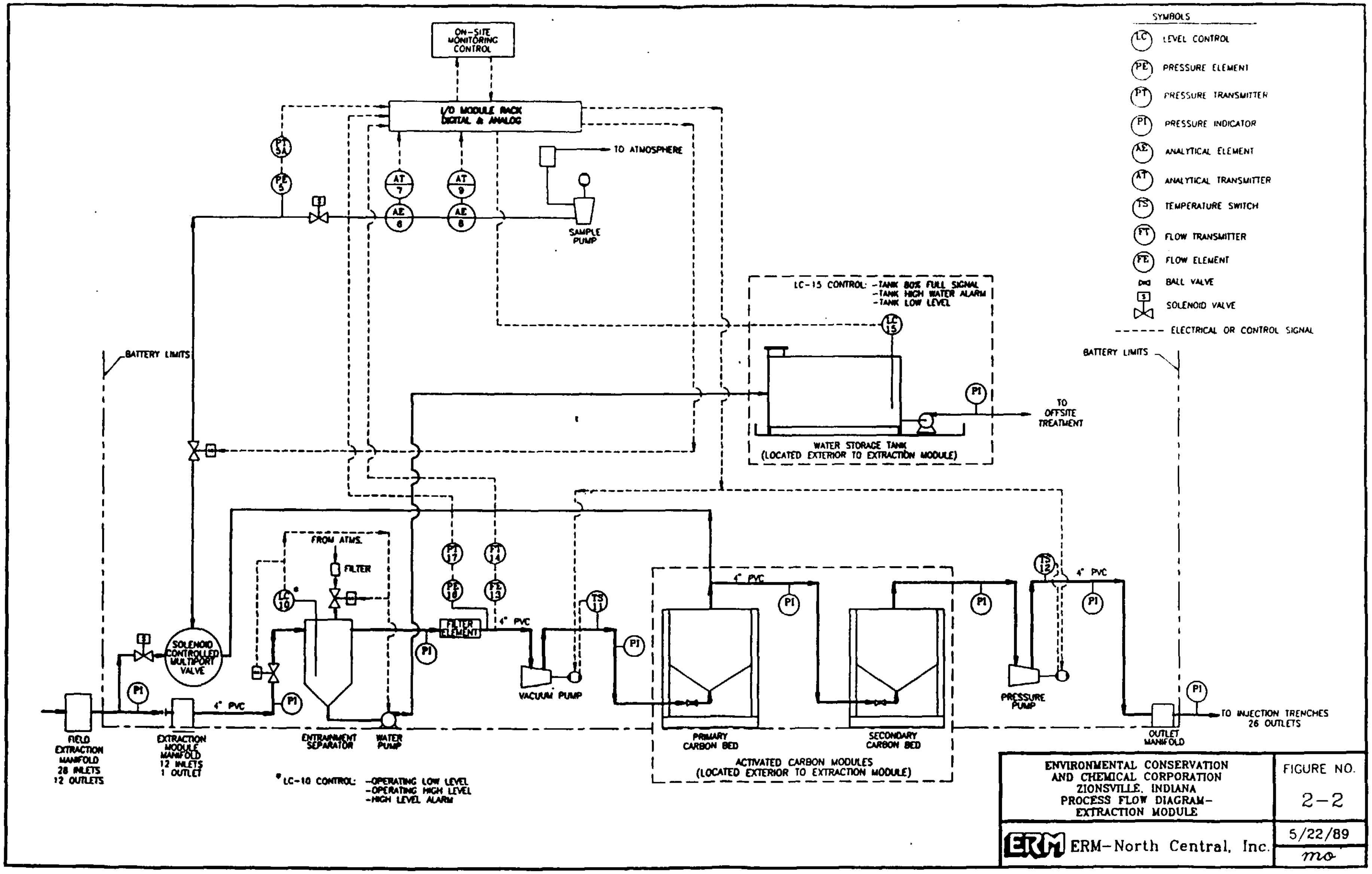
ENVIRONMENTAL CONSERVATION
AND CHEMICAL CORPORATION
ZIONSVILLE, INDIANA
PROCESS FLOW AND
INSTRUMENT DIAGRAM

FIGURE NO. 2-1

ERM-North Central, Inc.

6/23/89

cs


SYMBOLS
LC LEVEL CONTROL
PE PRESSURE ELEMENT
PT PRESSURE TRANSMITTER
PI PRESSURE INDICATOR
AE ANALYTICAL ELEMENT
AT ANALYTICAL TRANSMITTER
TS TEMPERATURE SWITCH
FT FLOW TRANSMITTER
FE FLOW ELEMENT
BALL VALVE
SOLENOID VALVE
ELECTRICAL OR CONTROL SIGNAL
ON-SITE MONITORING CONTROL
I/O MODULE RACK DIGITAL & ANALOG
TO ATMOSPHERE
SAMPLE PUMP
LC-15 CONTROL: -TANK 80% FULL SIGNAL
-TANK HIGH WATER ALARM
-TANK LOW LEVEL
BATTERY LIMITS
TO OFFSITE TREATMENT
WATER STORAGE TANK
(LOCATED EXTERIOR TO EXTRACTION MODULE)
FROM ATMS.
FILTER
SOLENOID CONTROLLED MULTIPORT VALVE
FILTER ELEMENT
4" PVC
VACUUM PUMP
PRESSURE PUMP
FIELD EXTRACTION MANIFOLD 28 INLETS 12 OUTLETS
EXTRACTION MODULE MANIFOLD 12 INLETS 1 OUTLET
ENTRAINMENT SEPARATOR
WATER PUMP
PRIMARY CARBON BED
SECONDARY CARBON BED
ACTIVATED CARBON MODULES
(LOCATED EXTERIOR TO EXTRACTION MODULE)
OUTLET MANIFOLD
TO INJECTION TRENCHES 26 OUTLETS
*LC-10 CONTROL: -OPERATING LOW LEVEL
-OPERATING HIGH LEVEL
-HIGH LEVEL ALARM
ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION
ZIONSVILLE, INDIANA
PROCESS FLOW DIAGRAM-EXTRACTION MODULE
FIGURE NO.
2-2
ERM-North Central, Inc.
5/22/89
mo

which boosts the pressure and reinjects air into a network of 26 injection trenches located throughout the site. Each injection trench is located between and parallel to a pair of extraction trenches. The injected air then migrates from the injection trench through the soil towards the extraction trench. As the air migrates through the soil towards the extraction trench, the organics are vaporized into the air stream. As described in Section 2.1.2, the RCRA-compliant (Subtitle C) cover will be placed over the entire trench network to prevent air and water infiltration into the system during operation.

The major system components are:

- Extraction and injection trenches;

- Soil vapor extraction system;

- Water collection system;

- Carbon adsorption system;

- Air injection system; and

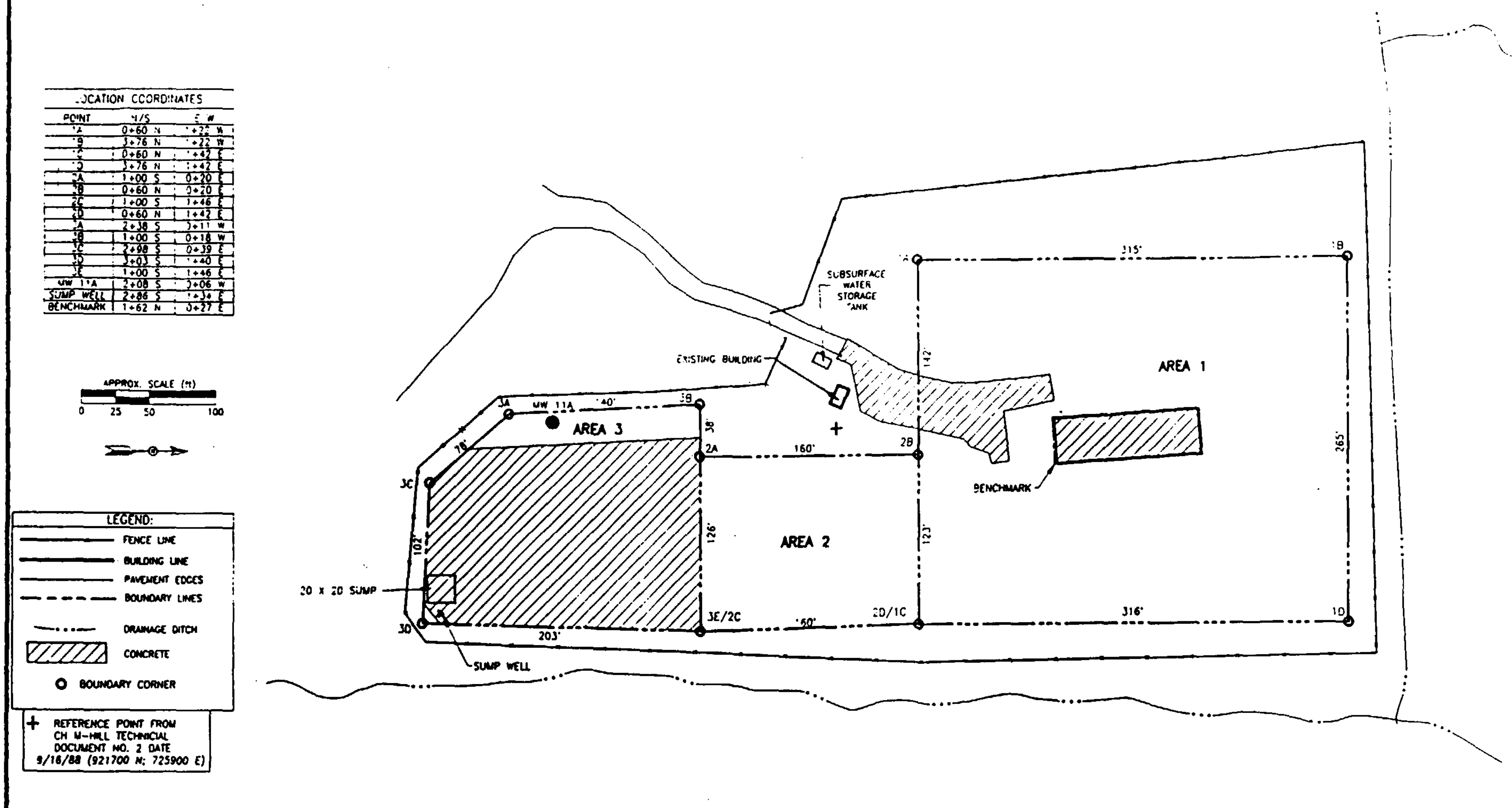
- RCRA-compliant (Subtitle C) cover.

A description of the design and operational features of each of these components is presented below.

Extraction and Injection Trenches

The area where remedial activity will occur is depicted in Figure 2-3. The west boundary of Area 1 encompasses the area of ECC

LOCATION COORDINATES		
POINT	N/S	E/W
1A	0+60 N	1+22 W
1B	3+76 N	1+22 W
1C	0+60 N	1+42 E
1D	3+76 N	1+42 E
2A	1+00 S	0+20 E
2B	0+60 N	0+20 E
2C	1+00 S	1+46 E
2D	0+60 N	1+42 E
3A	2+38 S	0+11 W
3B	1+00 S	0+18 W
3C	2+98 S	0+39 E
3D	3+03 S	1+40 E
3E	1+00 S	1+46 E
MW 11A	2+08 S	0+06 W
SUMP WELL	2+86 S	1+34 E
BENCHMARK	1+62 N	0+27 E



NOTE: DRAINAGE DITCHES WEST AND SOUTH OF SITE ARE NOT SHOWN ON EXISTING SITE SURVEYS. THESE DITCHES WILL BE VERIFIED AND SHOWN ON FINAL "PLANS AND SPECIFICATIONS".

ENVIRONMENTAL CONSERVATION
AND CHEMICAL CORPORATION
ZIONSVILLE, INDIANA
REMEDIAL ACTIVITY AREA

ERM ERM-North Central, Inc.

FIGURE NO. 2-3

7/21/89

cs

activities that resulted in hazardous substances being released, as verified by an examination of aerial photographs, and coincides with a pre-existing earthen berm which formed the western boundary of ECC's water containment system for this area.

The layout and construction details for the network of 28 extraction trenches and 26 injection trenches are presented in Figures 2-4 and 2-5. Trench spacing will be 18 feet, and trench length varies depending on the configuration of the site. Construction details of extraction trenches and injection trenches are identical. By implementing minor above-ground piping changes, injection trenches can and will be utilized as extraction trenches. The work required under this Remedial Action Plan will initially involve using the original extraction trenches for extraction; at some point in the process, the extraction trenches will be converted to injection trenches, and vice versa, to ensure complete vapor extraction of the soil.

All trenches are to be a minimum of 9-feet deep as measured from existing grade, and will be backfilled with washed "float" stone. The trench width will be 12-15 inches. The bottom elevation for both injection and extraction trenches will be sloped at a minimum of 1/16-inch per foot to a low point located at the water collection pipe as noted in Section A-A of Figure 2-5.

Soil removed from the trench excavation will be spread over the surface of the facility prior to construction of the cover system and covered in accordance with the final RCRA-compliant (Subtitle C) cover detail illustrated in Figure 2-5. Soil removed from the trenches constructed in the areas of the concrete pad (Area 3) will be spread over the surface in Areas 1 and 2 with trench spoils from those areas.

SEQUENCE OF CONSTRUCTION ACTIVITIES:

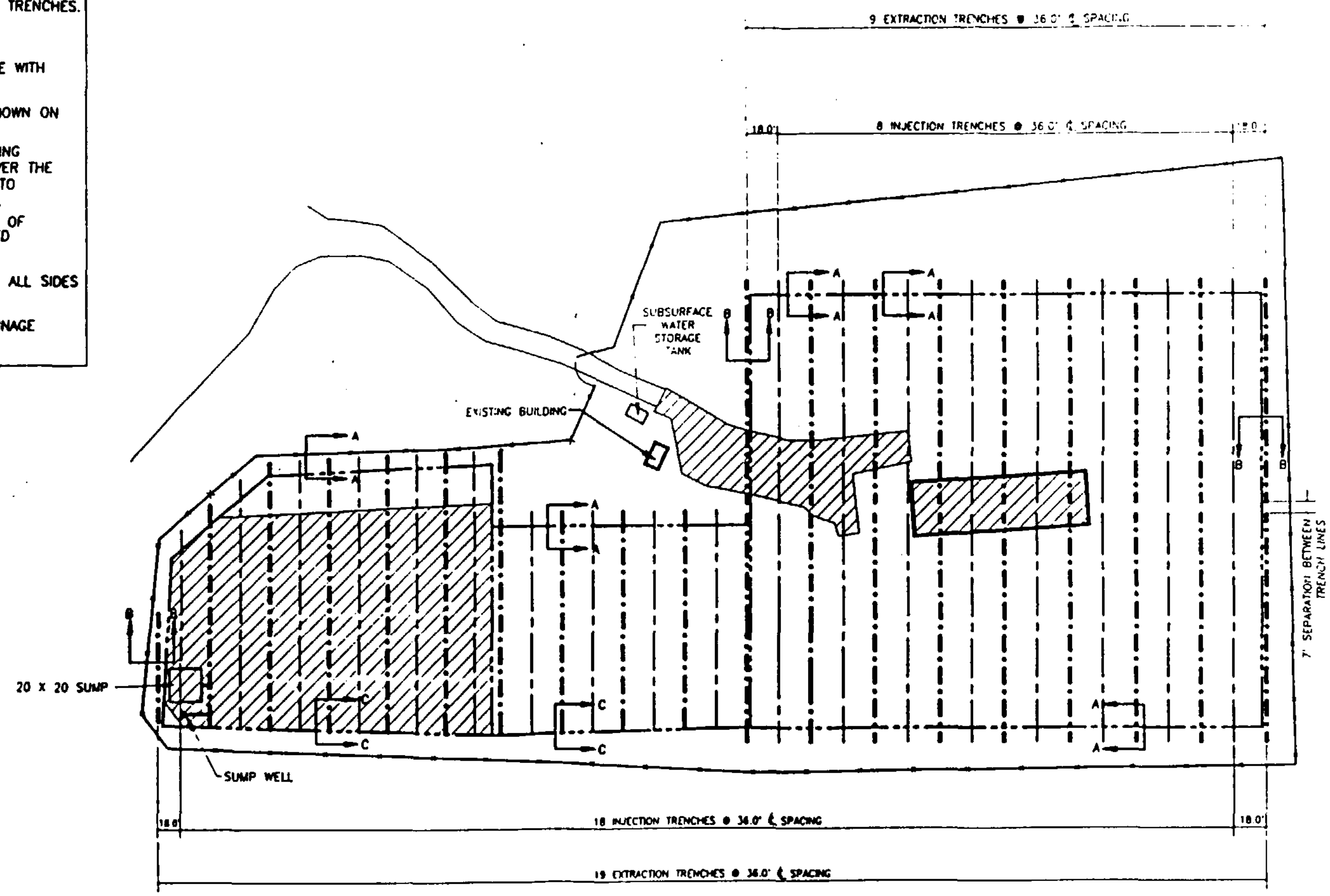
1. GRADE EXISTING TREATMENT SITE (AREA NOS. 1,2, & 3) TO EVEN SLOPE.
2. EXCAVATE INJECTION AND EXTRACTION TRENCHES.
3. FILL INJECTION TRENCHES WITH FLOAT STONE AS SHOWN ON FIGURE 2-5.
4. FILL EXTRACTION TRENCHES TO GRADE WITH FLOAT STONE AS SHOWN ON FIGURE 2-5.
5. EXCAVATE DEADMAN TRENCHES AS SHOWN ON FIGURE 2-6.
6. SOIL REMOVED FROM TRENCHES DURING CONSTRUCTION SHALL BE GRADED OVER THE SURFACE IN AREAS 1 AND 2 PRIOR TO INSTALLATION OF THE COVER SYSTEM.
7. COVER TREATMENT SITE WITH 1 FOOT OF NATIVE SOIL IN 6" LAYERS COMPACTED TO 95% PROCTOR DENSITY.
8. COVER TREATMENT SITE WITH 60 mil HDPE PLASTIC MEMBRANE ANCHORING ALL SIDES IN DEADMAN TRENCH AS SHOWN ON FIGURE 2-5.
9. COVER TREATMENT SITE WITH 6" DRAINAGE LAYER OF SAND AS SHOWN ON FIGURE 2-5.

APPROX. SCALE (ft)

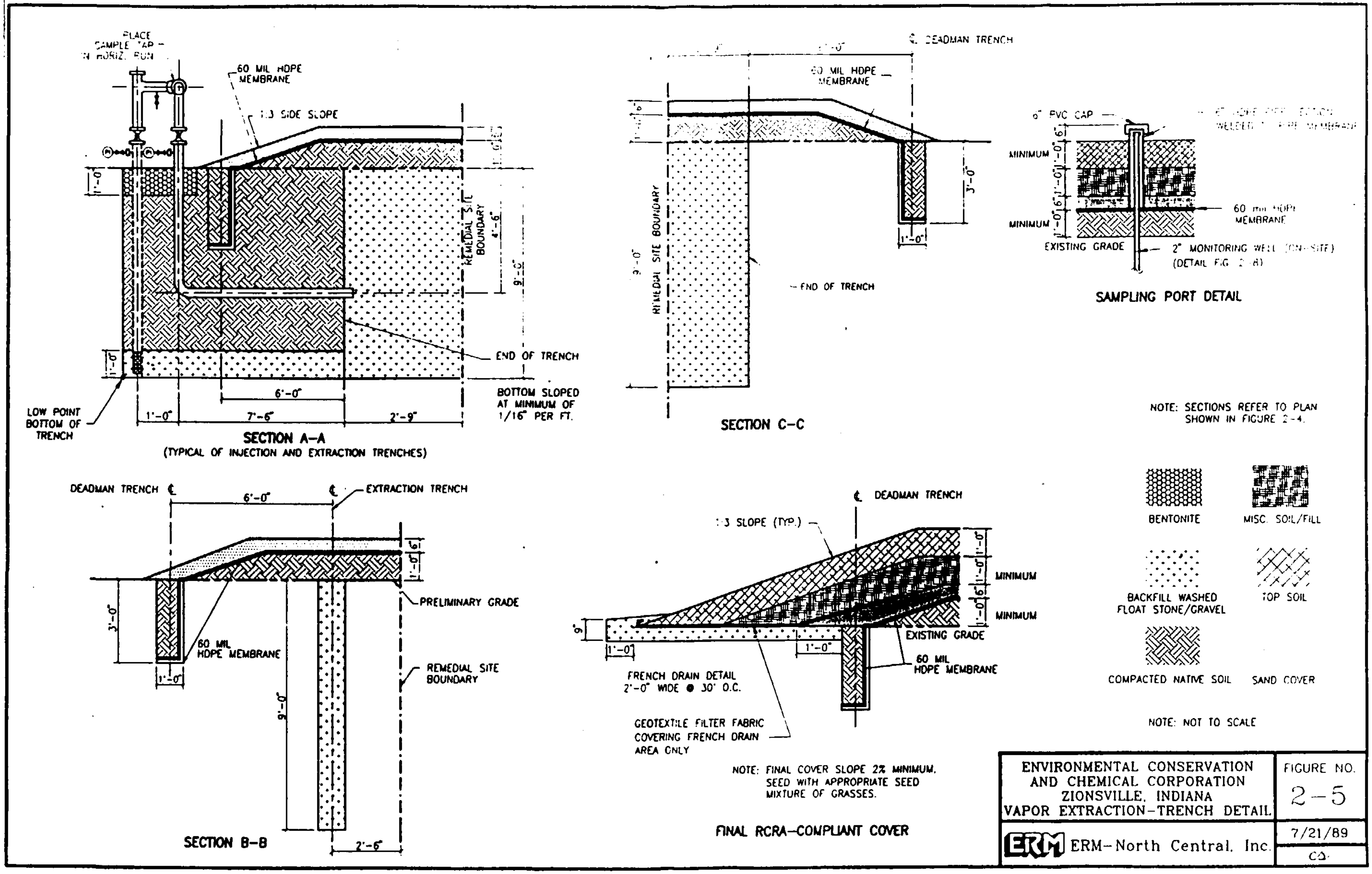
0 25 50 100

LEGEND:

- FENCE LINE
- BUILDING LINE
- PAVEMENT EDGES
- BOUNDARY LINES
- INJECTION TRENCHES
- EXTRACTION TRENCHES
- CONCRETE



ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION ZIONSVILLE, INDIANA SOIL VAPOR EXTRACTION-TRENCH PLAN	FIGURE NO. 2-4
ERM ERM-North Central, Inc.	7/21/89



PLACE SAMPLE TAP IN HORIZ. RUN
60 MIL HDPE MEMBRANE
1:3 SIDE SLOPE
REMEDIAL SITE BOUNDARY
4'-6"
9'-0"
1'-0"
END OF TRENCH
BOTTOM SLOPED AT MINIMUM OF 1/16" PER FT.
LOW POINT BOTTOM OF TRENCH
6'-0"
1'-0"
7'-6"
2'-9"
SECTION A–A
(TYPICAL OF INJECTION AND EXTRACTION TRENCHES)
℄ DEADMAN TRENCH
60 MIL HDPE MEMBRANE
REMEDIAL SITE BOUNDARY
3'-0"
1'-0"
END OF TRENCH
SECTION C–C
6" PVC CAP
MINIMUM
60 mil HDPE MEMBRANE
EXISTING GRADE
2" MONITORING WELL (ON-SITE)
SAMPLING PORT DETAIL
NOTE: SECTIONS REFER TO PLAN SHOWN IN FIGURE 2-4.
DEADMAN TRENCH ℄
℄ EXTRACTION TRENCH
6'-0"
PRELIMINARY GRADE
60 MIL HDPE MEMBRANE
REMEDIAL SITE BOUNDARY
3'-0"
9'-0"
1'-0"
2'-6"
SECTION B–B
℄ DEADMAN TRENCH
1:3 SLOPE (TYP.)
MINIMUM
MINIMUM
EXISTING GRADE
60 MIL HDPE MEMBRANE
FRENCH DRAIN DETAIL 2'-0" WIDE @ 30' O.C.
GEOTEXTILE FILTER FABRIC COVERING FRENCH DRAIN AREA ONLY
NOTE: FINAL COVER SLOPE 2% MINIMUM. SEED WITH APPROPRIATE SEED MIXTURE OF GRASSES.
FINAL RCRA–COMPLIANT COVER
BENTONITE
MISC. SOIL/FILL
BACKFILL WASHED FLOAT STONE/GRAVEL
TOP SOIL
COMPACTED NATIVE SOIL
SAND COVER
NOTE: NOT TO SCALE
ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION
ZIONSVILLE, INDIANA
VAPOR EXTRACTION–TRENCH DETAIL
FIGURE NO. 2–5
7/21/89
ERM ERM–North Central, Inc.

Each trench will be equipped at one end with a vapor extraction pipe and a water collection pipe as illustrated in Section A-A of Figure 2-5. Both pipes will be 4-inch diameter, Schedule 40 PVC. Each pipe segment will be equipped with pressure/vacuum indicator, isolating valve and sample tap. A "T" at the top of the water collection pipe will permit the future installation of air piping to air lift water from the trench network, if necessary. Individual 4-inch, Schedule 40 PVC pipes will be routed from each extraction trench to the extraction module. The extraction module will be located adjacent to the existing concrete pad near the site entrance. Alternatively, two or three extraction trenches will be manifolded together and conveyed to the extraction module via a 4-inch, Schedule 40 PVC pipe. Injection trench piping is identical to the extraction trench piping and, as previously described, will permit it to be utilized as an extraction trench during the operation of the vapor extraction system. To minimize field piping from the extraction module to the injection trenches, 4 to 8 injection trenches will be manifolded together. Four-inch, Schedule 40 PVC pipe will be used to convey air returned from the extraction module to the injection trench.

The Sump Well installed by EPA will be backfilled with the material used to backfill trenches (i.e, float stone) and a 4-inch PVC pipe will be installed between the Sump Well and the nearest extraction trench, thereby tying the Sump Well directly into the vapor extraction system. The existing 20 ft. x 20 ft. sump will be handled similarly, and will be dewatered prior to installing the RCRA-compliant (Subtitle C) cover system. All water removed from this sump will be handled in accordance with applicable Federal, State and local requirements.

Soil Vapor Extraction System

The vacuum pump will have a nominal capacity of 500 standard cubic feet per minute (SCFM) and will be capable of developing a vacuum of 18 inches Hg. The normal operating vacuum is anticipated to be 12 inches Hg. Based on MWRI's experience with soils characteristic of the ECC site and on the Terra Vac pilot study results at the ECC site, the zone of influence at the operating vacuum will be at least 40 feet (20 feet either side of the trench). The pilot test results showed an initial radius of influence of 15 feet during trench development. Under continuous operation, the radius of influence increased to about 20 feet. The enhanced operating efficiency obtained by installing an impervious cover and injecting air will increase the radius of influence to over 20 feet. To be conservative, a spacing between trenches of 18 feet was selected.

The vacuum will be applied at the trench outlet and will be distributed throughout the entire length and vertical dimension of the trench. The highly porous backfill material used will assure this uniform distribution of vacuum throughout the extraction trench. The reinjection pressure of air in each adjacent injection trench will be approximately 37.4 inches Hg (1.25 atm). Therefore, the pressure differential and driving force for air movement between injection and extraction trenches under normal operating conditions is approximately 19.4 inches Hg (0.65 atm).

The selection of the design air volume of 500 SCFM is based upon MWRI's experience and is consistent with the Terre Vac pilot plant test results. The criteria established is to provide at least one air volume change per soil pore volume per day. Based upon an area of treatment of 150,000 square feet, a depth of contamination of 9 feet, and a soil porosity of 10%, 500 SCFM exceeds the MWRI criteria by 400%.

The vapor extraction process will operate continuously and will shut down automatically only in the event of an operating problem or malfunction. The following are conditions which will shut down normal operating sequence of the vapor extraction system:

- High vapor temperatures above the estimated acceptable range of 150 to 180°F prior to activated carbon treatment;

- Low vapor temperatures below the estimated acceptable range of 75 to 85°F prior to activated carbon treatment indicating relative humidity above the estimated acceptable range;

- High water level in water entrainment separator indicating operating problems with liquid transfer operation;

- High water level in subsurface water storage tank;

- High or low pressure conditions on vacuum or injection pumps under normal operating conditions; and

- Power interruptions for the site.

During normal operation, vapor extraction will be stopped to facilitate carbon vessel change out as described later in this section and during transfer of water from the entrainment separator to the on-site subsurface water storage tank, or to conduct restart spike tests.

The air extracted from the system will be continuously monitored by in-line instrumentation as shown on the process flow diagram (Figure 2-2) and described on Table 2-1 (Instrument Summary Sheet). The capability will exist to sample individual trench exhausts or the combined air stream. Sample taps will be provided to collect vapor samples for detailed chemical analysis. The on-line instrumentation will consist of a photoionization detector (PID) and moisture analyzer. The vacuum pump, controls and instrumentation will be located in the Vapor Extraction Module Building.

Water Collection System

The high vacuum vapor extraction system selected will be capable of entrainment and movement of water which accumulates in the extraction trenches. Any free liquid in the extracted vapor will be separated by gravity in an entrainment separator located in the Vapor Extraction Module Building. A level control system will be utilized to control the removal of water which accumulates in the entrainment separator as required. The separator tank is equipped with a vacuum breaker system which will open the tank to the atmosphere to permit water to be transferred by pump from the separator to an on-site water storage tank as necessary. The time required to make this transfer will depend upon the equipment supplied by the vapor

TABLE 2-1
ERM-NORTH CENTRAL, INC.
INSTRUMENT SUMMARY SHEET

CLIENT: Environmental Conservation and Chemical Corporation

PROJECT NO.: 9041

DATE: 2/28/89 REVISED: 5/23/89

TAG NO.	SERVICE	REFERENCES MOUNTING PANEL	FIELD	SPEC SHEET	FLOW DIA.
PI	Pressure Indicator		X		2-1 2-2
PI-1 thru PI-4	Pressure Indicator with diaphram Seal and shutoff cock		X		2-1
PE-5	Pressure sensing element				
PT-5A	Pressure transmitter		X		2-2
AE-6	Moisture sensing element		X		2-2
AT-7	Moisture transmitter	X			2-2
AE-8	Volatile organics detector and quantifier	X			2-2
AT-9	Volatile organics quantified signal transmitter	X			2-2
LC-10	3-point water level control and alarm		X		2-2
TS-11	Gas temperature sensor with high level system shutdown switch		X		2-2
TS-12	Gas temperature sensor with high level system shutdown switch		X		2-2
FE-13	Gas flow measuring element		X		2-2
FT-14	Gas flow signal transmitter		X		2-2
LC-15	3-point water level control and alarm		X		2-2
PE-16	Pressure sensing element		X		2-2
PT-17	Pressure transmitter		X		2-2

extraction system vendor selected.

The size of the storage tank will be sufficient to store the liquids, considering the off-site handling/treatment option selected. If water collected from the soil vapor extraction system is to be discharged to the Northside Sanitary Landfill (NSL) pipeline, a 1,000-gallon storage tank will be used; or if water collected is to be hauled off-site by tank truck for disposal, a 10,000-gallon tank will be used. The tank will be equipped with level measurement and control to advise operating personnel to the status of liquid accumulation in the storage tank. Periodically, the contents of the water storage tank will need to be removed. The removed water will either be sent to the Indianapolis POTW via the NSL pipeline or truck, or to another off-site facility for handling and treatment as necessary, in accordance with applicable Federal, State and local regulations.

Carbon Adsorption System

From the water entrainment tank, the air passes through a particulate filter preceding the vacuum pump. The pressure drop across the filter will be monitored and used as the signal for determining servicing of the filter element. The exhaust from the vacuum pump will be piped directly to a two-stage carbon adsorption system (primary and secondary). This system will consist of two vessels in series each containing approximately 1,800 pounds of granular activated carbon. The organics contained in the extracted air will be adsorbed on the activated carbon. The moisture content of the air stream will be less than 50% relative humidity and temperatures will be approximately $150^{\circ}F$, both acceptable for efficient operation of carbon adsorption.

During the initial phases of operation, when organics concentrations in the air stream will be highest, the carbon capacity for the organics is expected to be about 25% by weight. During the latter phases of remediation as organic concentration of vapor decreases, the projected carbon capacity for organics will range between 10-15% by weight. Based upon an assumed total mass of organics of about 5,000 pounds (Appendix A), the total quantity of activated carbon required for the entire remediation program is 25,000 pounds. This equates to fourteen 1800-pound carbon vessels for the entire program. The actual amount of carbon used will depend upon the total mass of organics extracted during operation of the soil vapor extraction system and the carbon adsorption capacity.

The vapor from the primary carbon vessel will be monitored frequently (approximately once per hour) by an on-line PID analyzer. When the PID analyzer detects organic vapor in the air stream between the primary and secondary carbon vessels, the vacuum extraction system will shut down automatically to permit the removal and replacement of the "spent" primary carbon vessel. An operator will be alerted to this condition, and will disconnect the primary carbon bed from service. The spent carbon vessel will be removed and replaced by a carbon vessel containing fresh activated carbon. The unit previously serving as the secondary carbon bed will become the primary carbon bed and the unit just placed in operation will be the secondary carbon bed. Once this switch is complete, the soil vapor extraction system (i.e., vacuum pump and injection pump) will be restarted, and the system operation resumed. The arrangement of two activated carbon vessels in series (i.e., primary and secondary) will permit optimal utilization of the activated carbon, and efficient capture of the organics.

The spent carbon vessels will be stored on-site. The vessels will be stored on the existing concrete pad adjacent to the vapor extraction module building, inside the fenced area. An approximate location of this area is shown in Figure 2-4. The inlet and outlet connections to each vessel will be capped and sealed appropriately. Periodically when a truckload quantity of vessels has accumulated, and at the conclusion of the vacuum extraction program, the vessels containing the spent carbon will be transported in accordance with applicable Federal, State and local requirements to an off-site facility where the carbon will be regenerated by high temperature incineration, and in the process, the organics adsorbed on the carbon will be destroyed.

Air Injection System

The exhaust air from the secondary carbon bed will be piped to the injection pump located in the extraction module building. The injection pump will be capable of delivering 500 SCFM at 10 psig (1.65 atm). The discharge from the injection pump will be distributed to the 26 injection trenches via a system of manifolds. Control of the injection pump will be interlocked with the vacuum extraction pump. The pipe at each injection trench will be equipped with a pressure/vacuum gauge so that injection pressure at the trench can be periodically monitored.

During the soil vapor extraction program, the injection trenches will be utilized as extraction trenches and vice versa. This can be accomplished by minor above ground manifold piping modifications. It is also planned that as the Cleanup Standards set forth in Table 3-1 below are met for individual trench "areas", the corresponding extraction and injection trenches will be isolated from the extraction and injection operation by closing the shut off valves located at each trench. This will permit the soil vapor extraction system to concentrate on any remaining areas which have not fully achieved the Cleanup Standards specified in Table 3-1, thereby accelerating cleanup of those areas.

RCRA-Compliant (Subtitle C) Cover

The operation of the vapor extraction system will be enhanced by the installation of the RCRA-compliant (Subtitle C) cover over the entire site. Details and a schedule for installation of the final RCRA-compliant (Subtitle C) cover are presented in Section 2.1.2.

Miscellaneous

- Each extraction trench is equipped with two sample taps, one on the vacuum pipe and one on the water collection pipe. Each of these taps can be fitted with a sample bottle for the collection of free moisture.

- Electrical service required for the site remediation work is anticipated to be 3-phase 460 volt. Total electrical demand will be approximately 100 KVA. Power distribution will be to the extraction module building. Operating voltage for the extraction and injection pumps is anticipated to be 460 volts. A 110 volt supply will be provided for miscellaneous site lighting, equipment, instrumentation and controls. Power distribution to any site construction and office trailers will also be provided.

- Prior to construction of the trenches, the following activities will be conducted:

  1. The existing buildings within the area currently fenced will be demolished and properly disposed of off-site;

  2. The existing tanks removed and properly disposed of off-site; and

  3. The site will be graded to fill existing depressions and to eliminate any sharp grade changes.

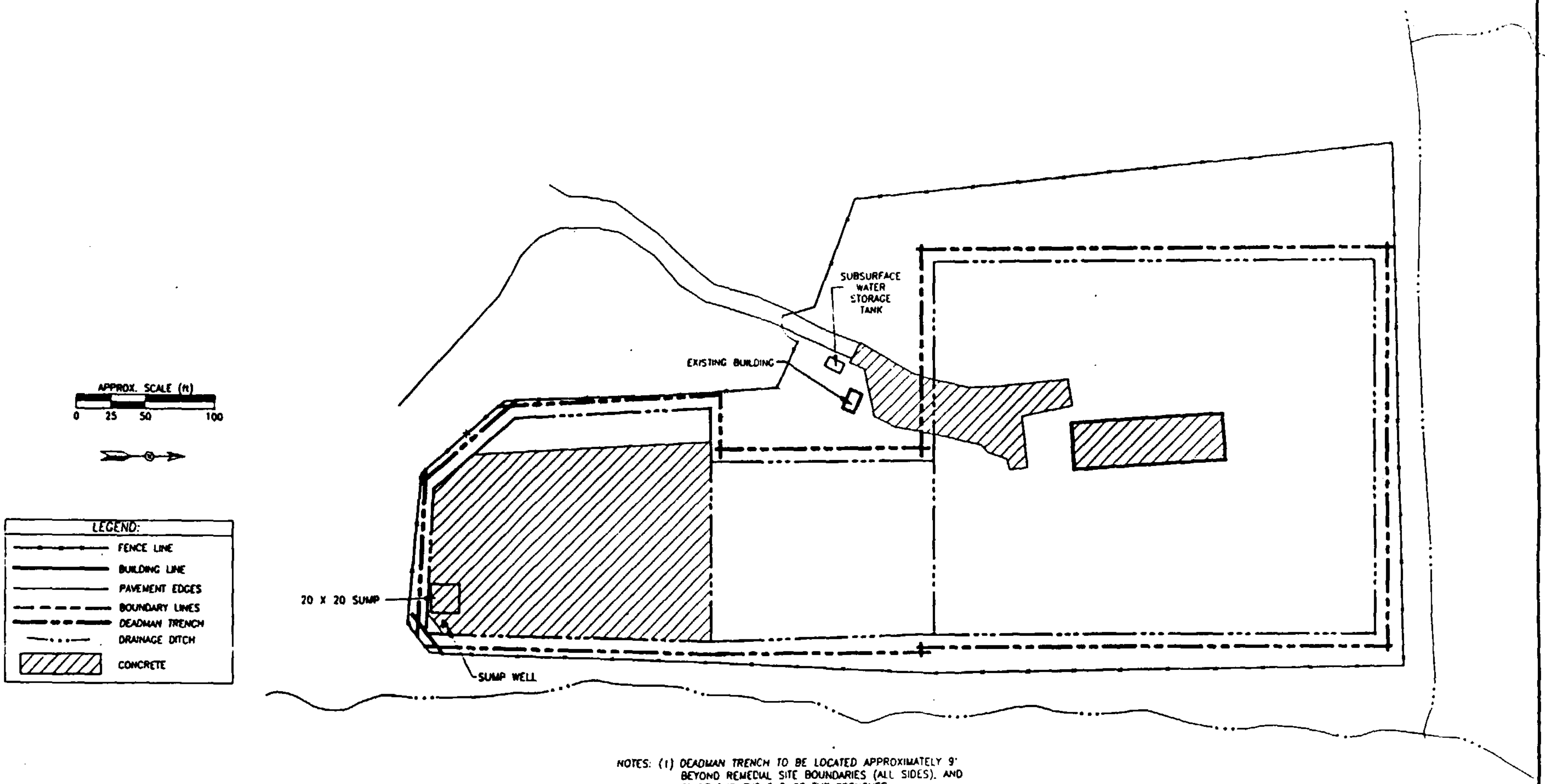
2.1.2 RCRA-Compliant (Subtitle C) Cover

The RCRA-compliant (Subtitle C) cover illustrated in Figure 2-5 will consist of a minimum of 1-foot of compacted, highly impermeable native soil, a continuous welded 60 millimeter high density polyethylene (HDPE) plastic membrane, a minimum 6-inch layer of compacted sand for drainage, 1 to 3 feet of miscellaneous soil/fill material and 1 foot of top soil to support vegetation. The final grading plan will ensure a minimum slope of 2%. The native soil used will be the silty clay till available in the area, which can and will be compacted by standard methods to 95% proctor density. If soil from the neighboring NSL Facility borrow area is not available, material with similar performance will be obtained by Settling Defendants from another source.

To provide a perimeter seal of the HDPE membrane, a 1-foot wide, 3-foot deep "deadman trench" will be installed around the site boundary (Figure 2-6). The HDPE membrane will be draped into this trench. The trench will then be backfilled and compacted with native soil (silty clay till) to 95% proctor density. The cover will extend approximately 6 feet beyond the deadman trench as noted on Figure 2-6 and detailed on Figure 2-5.

As previously described, the material excavated from the trenches will be graded uniformly throughout trench areas 1 and 2 and incorporated into the top layer of existing surface soil prior to the construction of the RCRA-compliant (Subtitle C) cover as shown in Figure 2-5.

The RCRA-compliant (Subtitle C) cover will be installed over the entire site, including the concrete pad. Prior to operation of the soil vapor extraction system, the following components of the RCRA-compliant (Subtitle C) cover will be installed: (1) 1-foot minimum compacted native soil; (2) a 60 mil HDPE membrane; and (3) 6 inches of sand. Prior to installation of the remaining components of the cap, Settling Defendants shall ensure that the aforesaid components of the cap meet the aforesaid specifications. The remaining components (1-foot minimum miscellaneous soil/fill, 1-foot minimum topsoil and appropriate vegetation) will then be installed in accordance with the schedule presented in Section 5.0. At completion of the soil vapor extraction program all surface piping will be removed from



NOTES: (1) DEADMAN TRENCH TO BE LOCATED APPROXIMATELY 9' BEYOND REMEDIAL SITE BOUNDARIES (ALL SIDES), AND 6' BEYOND THE END OF THE TRENCHES.

(2) DEADMAN TRENCH DEFINES THE BOUNDARY OF THE HDPE LINER. THE RCRA-COMPLIANT (SUBTITLE C) COVER DETAIL EXTENDS APPROXIMATELY 6' BEYOND THE DEADMAN BOUNDARY AS SHOWN ON FIG 2-5.

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION ZIONSVILLE, INDIANA DEADMAN TRENCHING PLAN	FIGURE NO. 2-6
ERM-North Central, Inc.	7/19/89
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the site in addition to any equipment, buildings or trailers. At that time the extraction and injection trench piping may be cut off at the current grade, filled with grout, and covered with a minimum of 1 foot of topsoil, which will be vegetated. Vegetation which will be established shall include fibrous, shallow, laterally growing roots, such as grass (which may include red fescue and Kentucky blue grass).

The Settling Defendants shall conduct periodic inspections and shall repair the cap as necessary to ensure its integrity in accordance with the time periods set forth in 40 CFR Sections 265.117 and .118 or 329 I.A.C. Sections 3-21-8 and -9.

2.1.3 Access Restrictions

Access restrictions to be implemented by the Settling Defendants will consist of a fence around the site perimeter and the posting of warning signs. In addition, Settling Defendants will use "best efforts", as that term is used in Section X A. of the Decree, to have recorded appropriate restrictions with the County Recorder's Office prohibiting: (a) usage of the site for excavation and development; (b) usage of ground water from the saturated till and the underlying sand and gravel; and (c) installation of new water wells other than monitoring wells.

2.1.4 Subsurface and Surface Water Monitoring

The monitoring activities will:

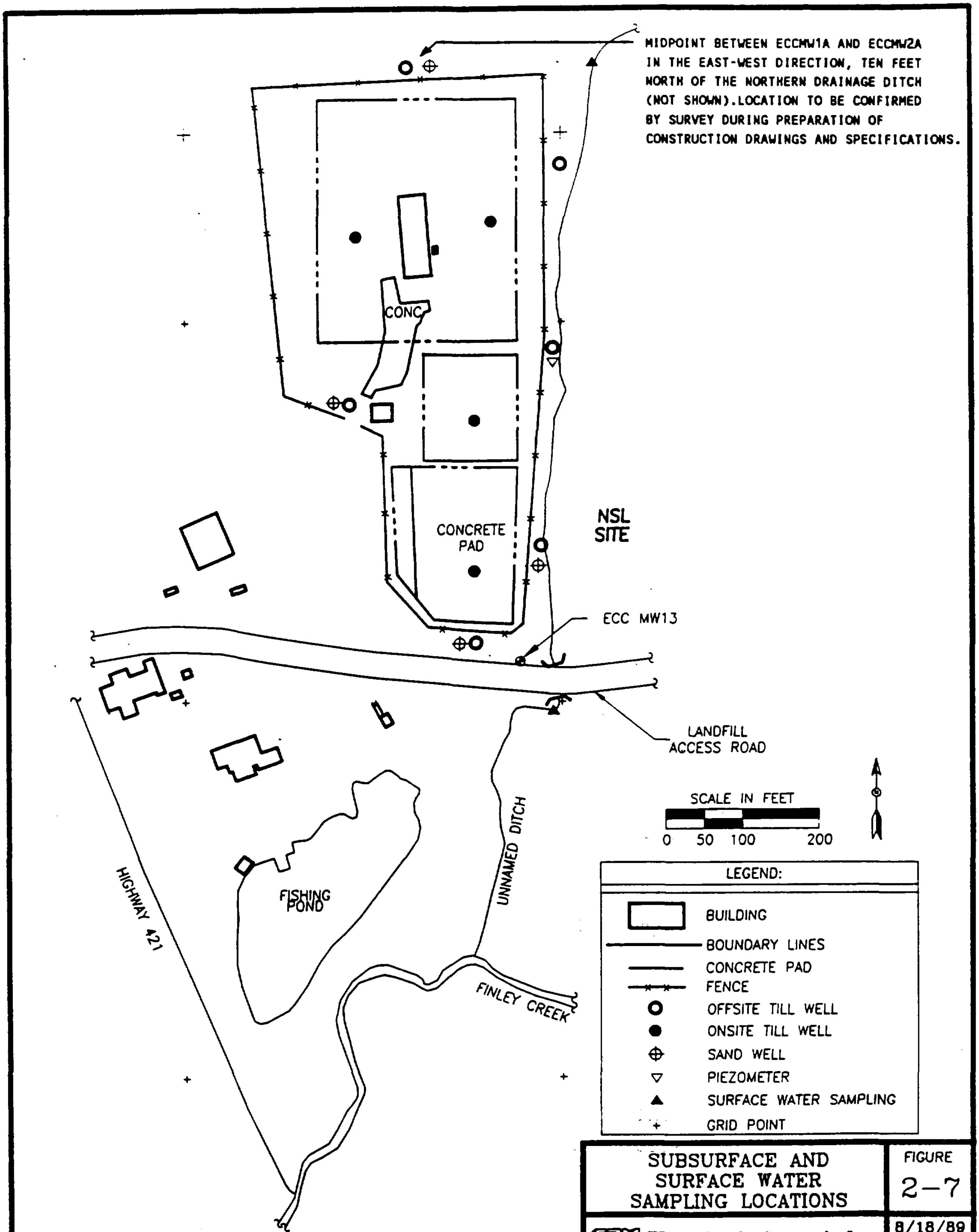
- o Detect the presence of the VOCs, base neutral/acid organics, PCBs, and heavy metals specified in Table 3-1 in the subsurface and surface water during and after vapor extraction; and

- Provide information to determine the effectiveness of the soil vapor extraction program.

Two types of subsurface water monitoring systems will be installed under this Remedial Action Plan. The first is an on-site till monitoring system consisting of four wells screened in the saturated zone of the till. The location of these on-site till wells is shown in Figure 2-7. Sampling results from the on-site till wells will be compared to the Acceptable Subsurface Water Concentrations in Table 3-1 or the Applicable Subsurface Water Background Concentrations of Table 3-1 ("Applicable Subsurface Water Background Concentrations").

Samples from the on-site till monitoring wells will be collected at the beginning of the soil vapor extraction operation and quarterly thereafter until completion of the soil vapor extraction program. Monitoring will be continued on a semi-annual basis as specified in Section 4.0. Every time samples are collected from the on-site wells, the soil vapor extraction system will be shut down to allow water, if any, to stabilize within the till. Samples collected from the on-site wells will be analyzed for those parameters listed under Acceptable Subsurface Water Concentrations in Table 3-1.

The second type of subsurface water monitoring system consists of off-site wells screened in the till and offsite wells screened in

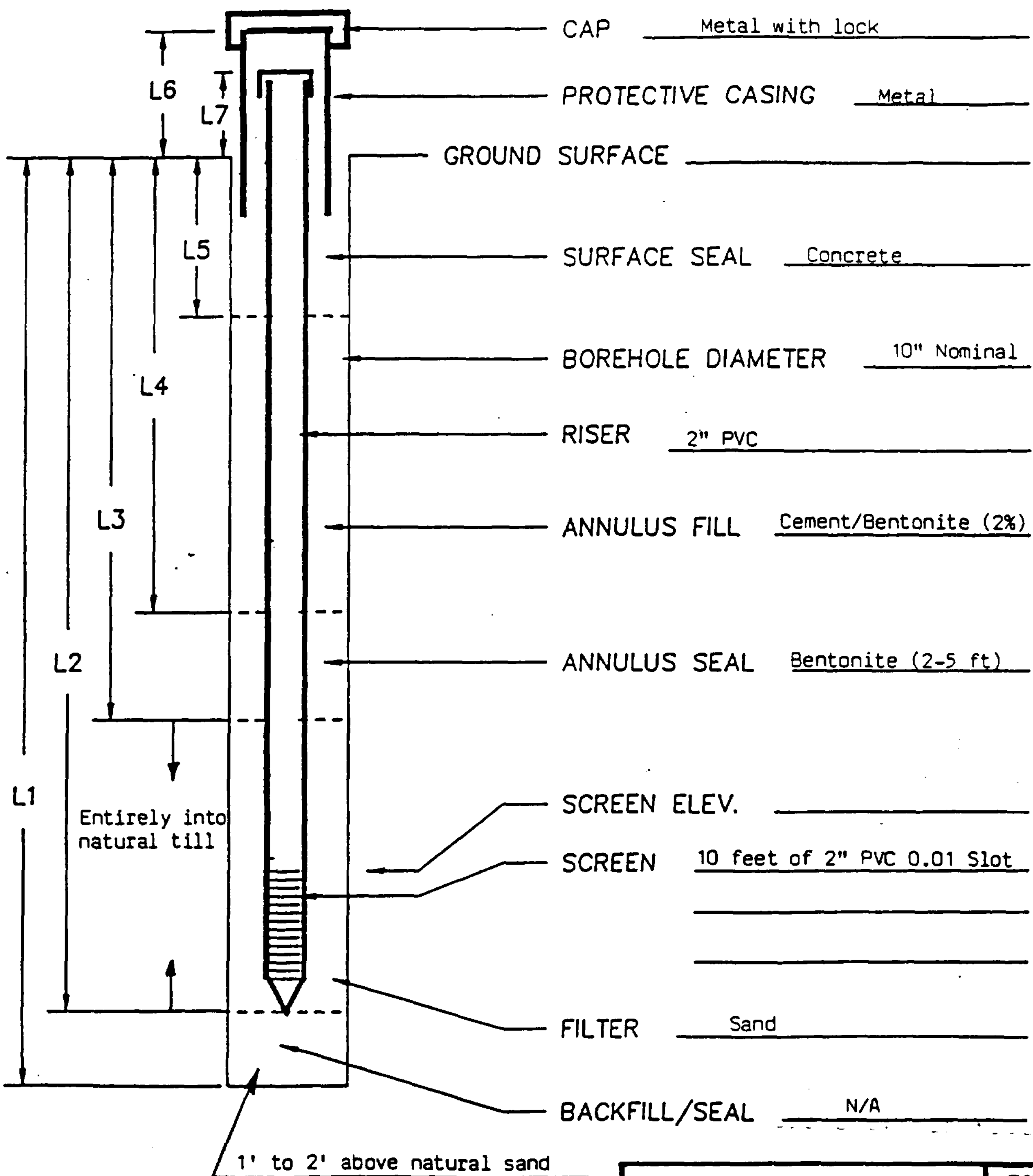


SUBSURFACE AND SURFACE WATER SAMPLING LOCATIONS	FIGURE 2-7
ERM ERM-North Central, Inc.	8/18/89

the sand and gravel. Sampling results from these wells will be used to determine compliance with the Acceptable Stream Concentrations in Table 3-1 or the Applicable Surface Water Background Concentrations of Table 3-1. This second subsurface water monitoring network will consist of ten (10) new wells, which will be located around the periphery of and downgradient from the ECC site, and one existing monitoring well, ECC MW-13 (Figure 2-7). In addition, a piezometer will be installed on the east side of the site, as shown in Figure 2-7, to aid in defining the direction of subsurface water flow in the sand and gravel. Six (6) wells will be installed in the till, completed in the saturated zone, and four (4) wells will be completed in the sand and gravel unit underlying the saturated surface till.

All wells (on-site and off-site) will be constructed of 2-inch PVC pipe. Screen length will vary for each well. Total depth for the wells completed in the till will be 1-2 feet less than total depth to the contact between the till and underlying sand and gravel. Wells completed in the sand and gravel will screen the total thickness of that sand and gravel unit. Screens will have a 0.01 inch opening. Wells will have a sand pack to one foot above the top of screen and a bentonite grout to the ground surface. For the on-site till wells, a sampling port will be fabricated in the HDPE membrane which will prevent infiltration of air via these monitoring wells during operation of the soil vapor extraction system. A detail of this sampling port is shown on Figure 2-5. Figures 2-8 and 2-9 illustrate well construction details for the subsurface water monitoring wells in the till and in the sand and gravel, respectively. Details of the piezometer construction are shown in Figure 2-10. The location of the monitoring wells is based on the subsurface water elevation contours shown in Figure 2-11.

MONITORING WELL CONSTRUCTION



ECC - Typical Monitoring Well Construction Detail Well in Glacial Till

FIGURE 2-8

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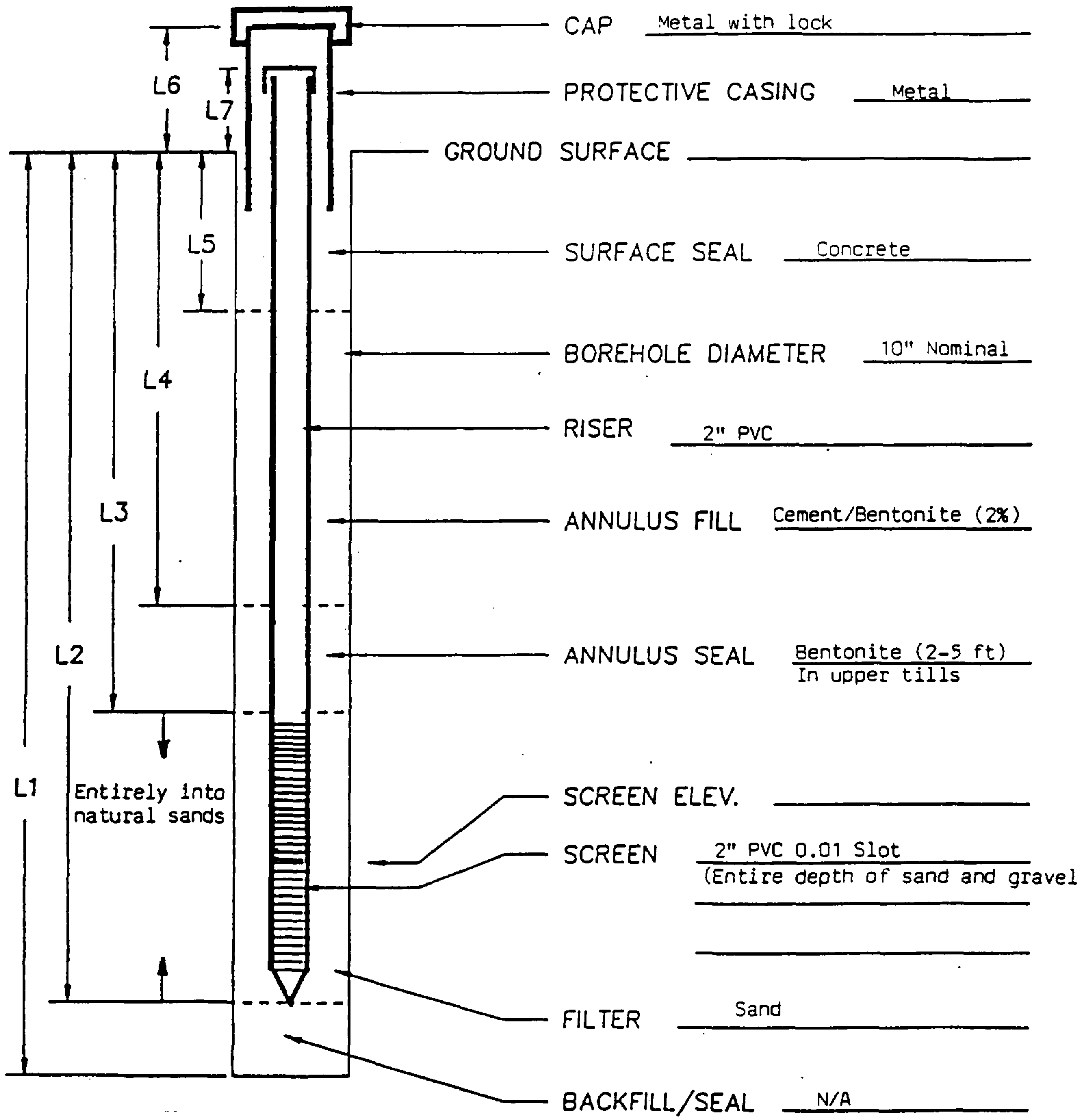
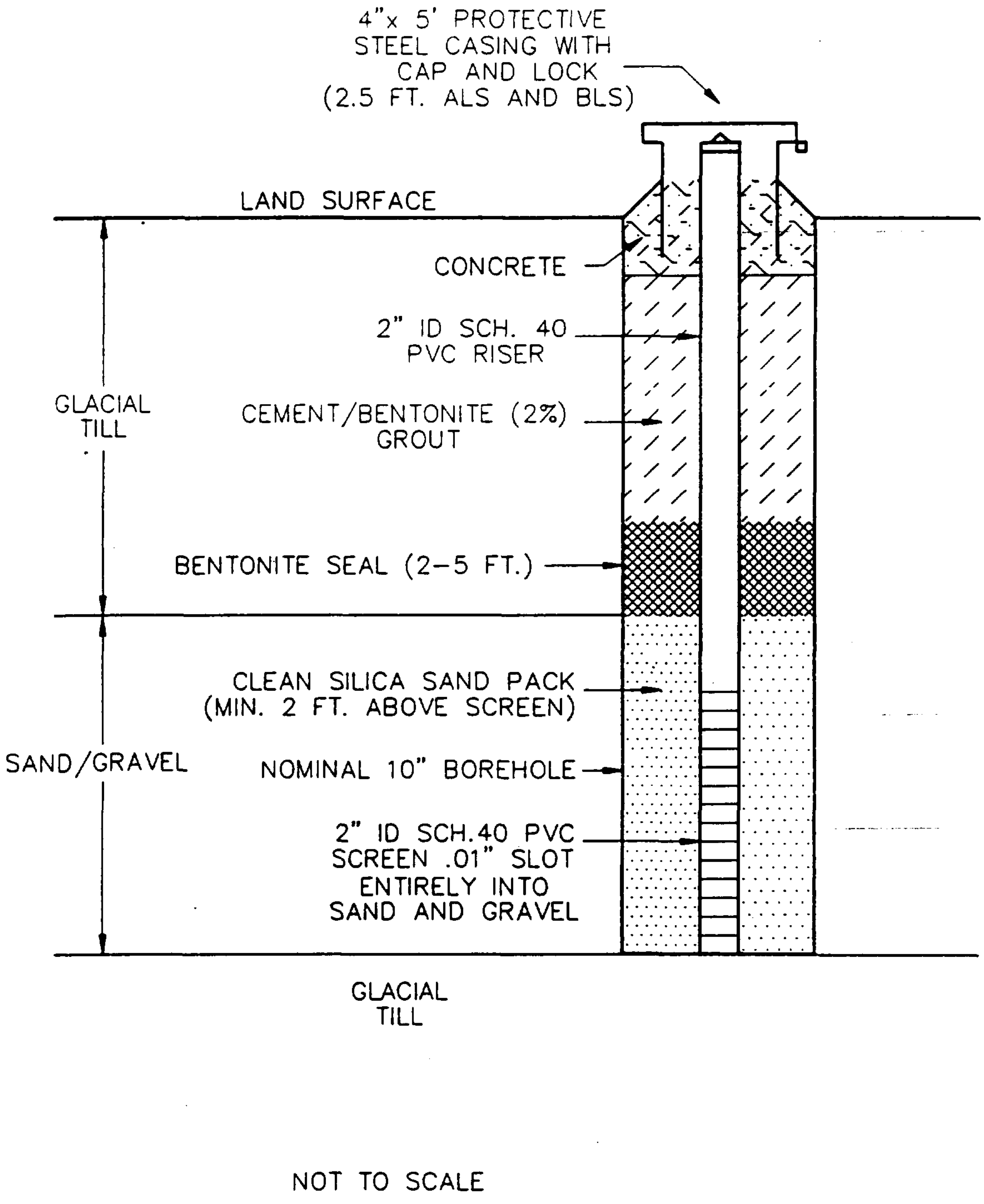
MONITORING WELL CONSTRUCTION



ECC - Typical Monitoring Well Construction Detail Well in Sand & Gravel	FIGURE 2-9
ERM ERM-North Central, Inc.	



ECC–TYPICAL PIEZOMETER CONSTRUCTION DETAIL INSTALLED IN SAND AND GRAVEL

FIGURE 2–10

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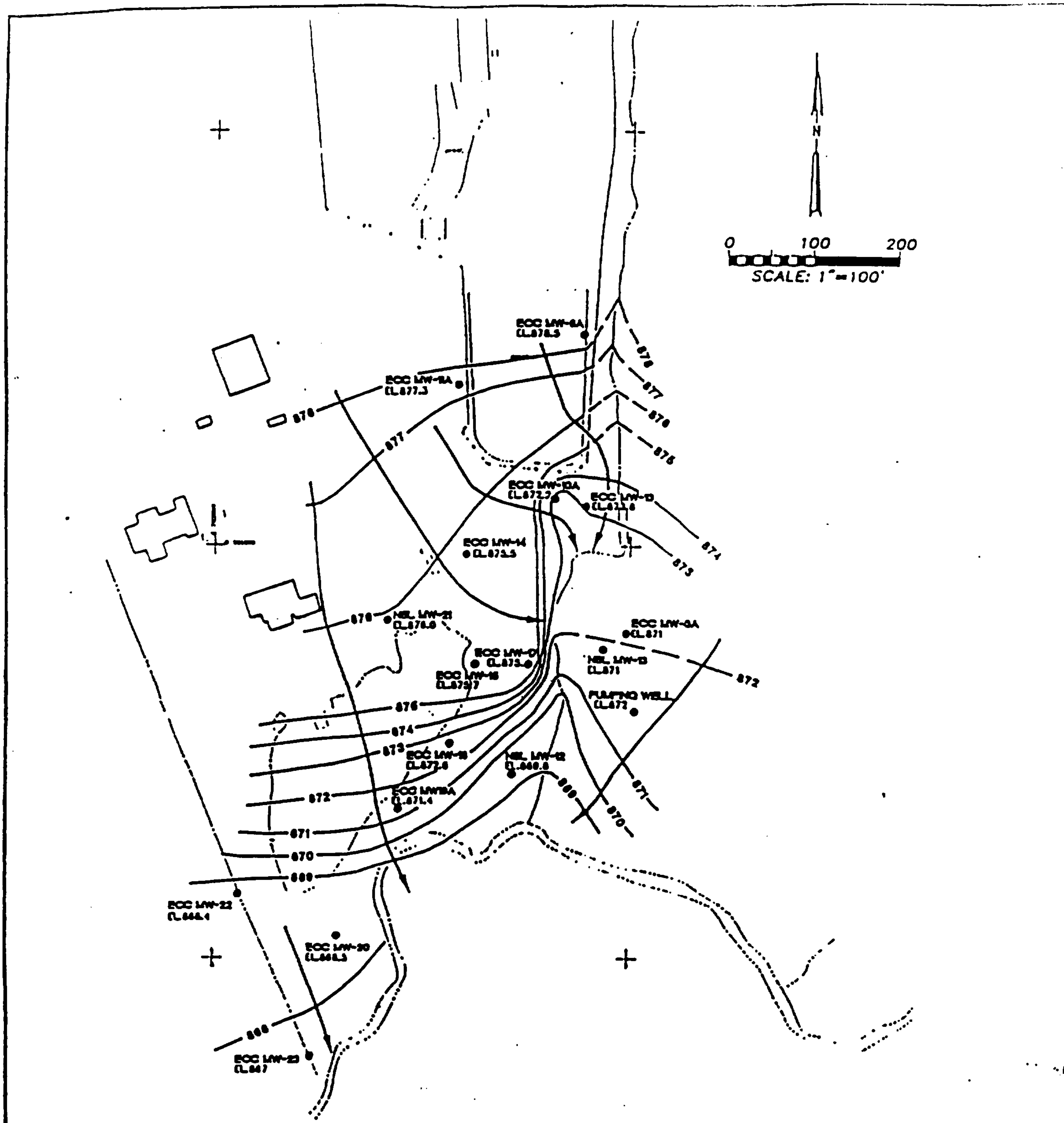

LEGEND

~868~ POTENTIOMETRIC SURFACE CONTOUR FOR SAND AND GRAVEL AQUIFER. CONTOUR INTERVAL: 1 FOOT.

— — 868 — — INFERRED POTENTIOMETRIC SURFACE CONTOUR

———→ DIRECTION OF GROUNDWATER MOVEMENT IN SURFICIAL AQUIFER

NOTE: Contours have been drawn to suggest that the pond is not hydraulically connected to the sand and gravel aquifer. This relationship has not been fully established.

From CH2M HILL Technical Memorandum No. 2, dated September 16, 1988.

POTENTIOMETRIC SURFACE MAP OF UPPER SAND AND GRAVEL AQUIFER	FIGURE 2-11
ERM ERM-North Central, Inc.	10/27/88
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Samples from the off-site wells will be collected quarterly during operation of the vapor extraction system and analyzed for the parameters with Acceptable Stream Concentrations in Table 3-1. Monitoring will be continued on a semi-annual basis as specified in Section 4.0.

The surface water will be monitored by sampling the Unnamed Ditch just upgradient and just downgradient of the ECC site as depicted in Figure 2-7. Surface water will be sampled at the same frequency as the off-site subsurface water and analyzed for the parameters with Acceptable Stream Concentrations in Table 3-1.

3.0 REMEDIAL ACTION CLEANUP STANDARDS

This section presents site-specific Cleanup Standards to be used at the ECC site as the criteria for determining completion of remedial action. The Cleanup Standards in this section are the basis for establishing the criteria for Soil Cleanup Verification presented in Section 4.2, and the Post-Soil Cleanup Verification Compliance Monitoring in Section 4.3. If Soil Cleanup Verification as defined in Section 4.2 and the subsections thereof is not achieved within 5 years of commencing operation of the soil vapor extraction system, the Additional Work provisions of Section VII of the Consent Decree will apply.

3.1 Cleanup Standards

The following Cleanup Standards will be met for successful completion of the soil vapor extraction program:

- o Acceptable Soil Concentrations shown in Table 3-1 will be achieved according to the procedure discussed in Section 4.2.3 of Exhibit A;

- o Acceptable Stream Concentrations or Applicable Surface Water Background Concentrations shown in Table 3-1 will be achieved in Unnamed Ditch south of and adjacent to ECC;

- o Acceptable Subsurface Water Concentrations or Applicable Subsurface Water Background Concentrations shown in Table 3-1) in the on-site till wells will be achieved; and

- o Acceptable Stream Concentrations or Applicable Surface Water Background Concentrations shown in Table 3-1 in the off-site wells will be achieved.

The term "Table 3-1" wherever referred to or used in this Exhibit A and in the Consent Decree includes the Footnotes on pages 2 and 3 of 3 of that table.

3.2 Calculation of Cleanup Standards

Table 3-1 sets forth the ECC site specific Cleanup Standards and

TABLE 3-1 (Page 1 of 2)
SITE-SPECIFIC ACCEPTABLE CONCENTRATIONS
ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION (ECC) SITE

Compounds	Acceptable Subsurface Water Concentration (1,2) (ug/l)		Acceptable Stream Concentration (3,4) (ug/l)	Acceptable Soil Concentration (5,6) (ug/kg)
VOLATILE ORGANICS (VOCs):				
Acetone	3,500	RB		490
Chlorobenzene	60	MCLGP		10,100
Chloroform	100	MCL	15.7	2,300
1,1-Dichloroethane	0.38	RB		5.7
1,1-Dichloroethene	7	MCL	1.85	120
Ethylbenzene	680	MCLGP	3,280	234,000
Methylene Chloride	4.7	RB	15.7	20
Methyl Ethyl Ketone	170	LDWHA		75
Methyl Isobutyl Ketone	1,750	RB		8,900
Tetrachloroethene	0.69	RB	8.85	130
Toluene	2,000	MCLGP	3,400	238,000
1,1,1-Trichloroethane	200	MCL	5,280	7,200
1,1,2-Trichloroethane	0.61	RB	41.8	22
Trichloroethene	5	MCL	80.7	240
Total Xylenes	440	MCLGP		195,000
BASE NEUTRAL/ACID ORGANICS:				
Bis(2-ethylhexyl)phthalate	2.5	RB	50,000	
Di-n-Butyl Phthalate	3,500	RB	154,000	
Diethyl Phthalate	28,000	RB	52,100	
Isophorone	8.5	RB		
Naphthalene	14,000	RB	620	
Phenol	1,400	RB	570	9,800
INORGANICS:				
Antimony	14	RB		
Arsenic	50	MCL	0.0175	
Barium	1,000	MCL		
Beryllium	175	RB		
Cadmium	10	MCL		
Chromium VI	50	MCL	11	
Lead	50	MCL	10	
Manganese	7,000	RB		
Nickel	150	LDWHA	100	
Silver	50	MCL		
Tin	21,000	RB		
Vanadium	245	RB		
Zinc	7,000	RB	47	
Cyanide	154	LDWHA	5.2	
PESTICIDES/PCBs:				
PCBs	0.0045	RB (7)	0.000079 (7,8)	

TABLE 3-1 (Page 2 of 2)
SITE-SPECIFIC ACCEPTABLE CONCENTRATIONS
ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION (ECC SITE)

NOTES:

(1) RB = Risk-based standard. U.S. EPA, Draft RCRA Facility Investigation Guidance, 1987.
MCL = Drinking water Maximum Contaminant Level. 40 CFR 141
MCLGP = Drinking water MCL goal, proposed. U. S. EPA Superfund Public Health Evaluation Manual, update of November 16, 1987.
LDWHA = Lifetime drinking water health advisory. U.S. EPA, Superfund Public Health Evaluation Manual, update of November 16, 1987.

(2) In the event that higher concentrations than those set forth for any parameter in this column are present in the upgradient subsurface water in the till and/or sand and gravel according to the procedure specified below, then those higher upgradient subsurface water concentrations and not the values set forth in this table shall constitute the Acceptable Subsurface Water Concentrations within the meaning of this Exhibit A and the Consent Decree. Those upgradient subsurface water concentrations are referred to in this Exhibit A as "Applicable Subsurface Water Background Concentrations." Twelve subsurface water samples will be taken from existing or new well locations, approved by EPA, over at least a 12 month period in areas upgradient of the site. The exact procedure, location of wells, and schedule for collecting and analyzing the samples will be approved by EPA, after consultation with the State, prior to its implementation. Subsurface samples for inorganics and PCB analysis will be filtered. For each parameter, the analytical results from the 12 samples will be analyzed using standard statistical procedures. The mean and standard deviation will be calculated, and all non-detects will be assigned a value equal to 1/2 the EPA-approved quantification limit. For purposes of this Document, "Applicable Subsurface Water Background Concentrations" is defined as two (2) standard deviations above the calculated mean of these 12 samples.

(3) Stream Criteria, from Table 1 of the Record of Decision for the site, September 25, 1987.

(4) In the event that higher concentrations than those set forth for any parameter in this column are present in the upstream surface water, then those higher upstream concentrations and not the values set forth in this table shall constitute the Acceptable Stream Concentrations within the meaning of this Exhibit A and the Consent Decree. Those higher upstream surface water concentrations are referred to in this Exhibit A as

"Applicable Surface Water Background Concentrations." Twelve surface water samples will be taken from Unnamed Ditch upstream of the site over at least a 12 month period. The exact procedure, location of samples, and schedule for collecting and analyzing the samples will be approved by EPA, after consultation with the State, prior to its implementation. For each parameter, the analytical results from the 12 samples will be analyzed using standard statistical procedures. The mean and standard deviation will be calculated, and all non-detects will be assigned a value equal to 1/2 the EPA-approved quantification limit. For purposes of this Document, "Applicable Surface Water Background Concentrations" is defined as two (2) standard deviations above the calculated mean of these 12 samples.

(5) Acceptable Soil Concentration is based on ingestion of subsurface water at the site boundary, assuming a dilution of leachate to subsurface water of 1:196 (Appendix B).

(6) The Acceptable Soil Concentrations, within the meaning of this Exhibit A and the Consent Decree, will be achieved when the arithmetic average of the 20 soil sample results for each parameter, assigning all non-detect results a value of one-half the detection limit, do not exceed the values set forth in this table by more than 25 percent.

(7) So long as the EPA-approved quantification limit for PCBs in water is above the acceptable subsurface water and stream concentrations for PCBs, compliance with the Acceptable Subsurface and Stream Concentrations for PCBs will be determined as follows: all subsurface and surface water sample results for PCBs must be below the EPA-approved quantification limit for PCBs (at the time compliance is determined).

(8) Modified from Superfund Public Health Evaluation Manual, October, 1986, EPA 4/540/1-86/060, OSWER Directive 9285.4-1.

the procedure for determining Applicable Surface Water and Subsurface Water Background Concentrations. The equations for calculation of the risks, supporting data and complete references are included in Appendix B.

The calculation of risk-based concentrations shown in Table 3-1 follows the procedures presented in the USEPA Draft RCRA Facility Investigation (RFI) Guidance, July, 1987, and in the USEPA Memorandum on Interim Final Guidance for Soil Ingestion Rates, January 27, 1989. In accordance with this latter reference, the soil ingestion rate for risk calculation was either 0.1 grams of soil per day for a 70 kilogram person for 70 years (for compounds with potency factors) or 0.2 grams of soil per day for a 17 kilogram child for 5 years (for compounds with reference doses). In accordance with the RFI Guidance document referenced above, the ingestion rate used for the risk calculation was 2 liters of water per day by a 70 kg person for 70 years.

Three columns of data, corresponding to Acceptable Concentrations for Subsurface Water, Stream and Soil are presented in Table 3-1. Additionally, Applicable Subsurface Water Background Concentrations, and Applicable Surface Water Background Concentrations are defined in Table 3-1. The Acceptable Subsurface Water Concentrations are based on either drinking water standards or criteria (Maximum Contaminant Level [MCL], proposed Maximum Contaminant Level Goal [MCLGP], lifetime drinking water health advisory [LDWHA]) or the appropriate risk-based concentration. These limits assume, as a worst case, that the subsurface water in the till could be utilized as a lifetime source of drinking water. However, the use of the subsurface water in the till as a source of drinking water was rejected as unlikely in the ECC Remedial Investigation (RI), page 6-22. As a result, the use of drinking water standards and risk-based standards based upon daily, long-term human consumption of the till water for Cleanup Standards under this Remedial Action Plan represents an extremely conservative assumption when the real-life risks, if any, presented by the ECC site are considered.

The Acceptable Stream Concentrations are taken from the Record of Decision (ROD) for the site, dated September 25, 1987.

The Acceptable Soil Concentrations in Table 3-1 are based on the lowest of the risk-based concentrations for soil or subsurface water ingestion, from Tables B5 and B6.

Table 3-2 presents the compounds detected in soils at the site at levels above the Acceptable Soil Concentrations specified in Table 3-1. Table 3-3 shows the vapor pressure and solubility of these compounds.

3.3 Additional Work

If Additional Work is required under Section VII of the Consent Decree, Settling Defendants shall perform the following additional work at the site unless the parties agree otherwise:

- Maintain the RCRA-compliant (Subtitle C) cover and the access restrictions.

- Construct a subsurface water interception trench around the south and east sides of the ECC site as depicted in Figures 3-1 and 3-2.

- Collect and transport subsurface water

NOTES:

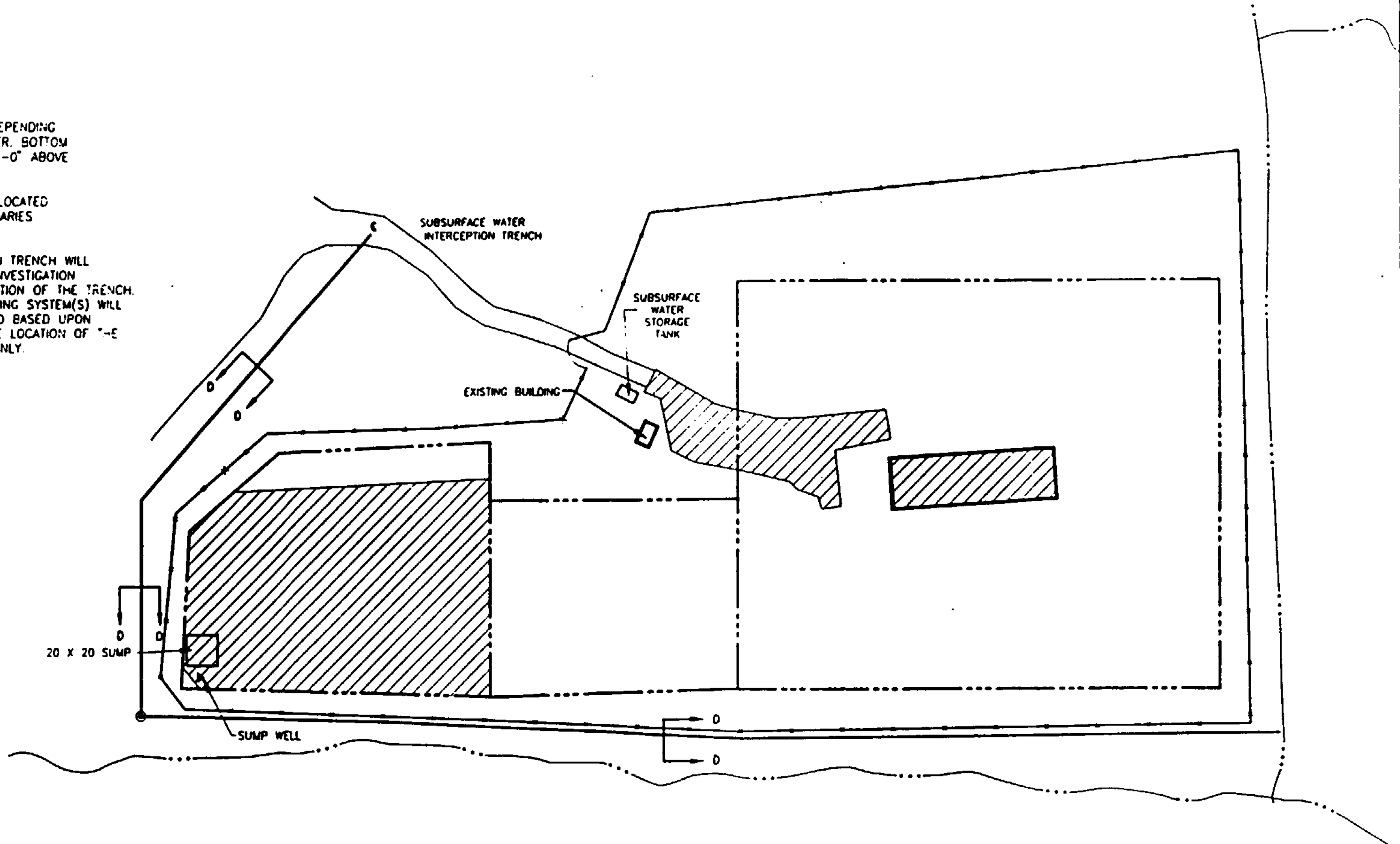
1) DEPTH OF TRENCH WILL VARY DEPENDING ON DEPTH OF GLACIAL TILL LAYER. BOTTOM OF TRENCH TO BE LOCATED ~1'-0" ABOVE UNDERLYING GLACIAL SAND.

2) INTERCEPTION TRENCH WILL BE LOCATED BETWEEN REMEDIAL AREA BOUNDARIES AND UNNAMED DITCH.

3) LOW POINT(S) FOR INTERCEPTION TRENCH WILL BE DETERMINED DURING FIELD INVESTIGATION WORK REQUIRED FOR CONSTRUCTION OF THE TRENCH. SUMP(S) AND ASSOCIATED PUMPING SYSTEM(S) WILL BE CONSTRUCTED AND INSTALLED BASED UPON LOCATION OF LOW POINT(S). THE LOCATION OF THE SUMP SHOWN IS ILLUSTRATIVE ONLY.

APPROX. SCALE (ft)

0 25 50 100



LEGEND:

—•—•—	FENCE LINE
━━━	BUILDING LINE
———	PAVEMENT EDGES
— - — -	BOUNDARY LINES
●	TRENCH SUMP & PUMP
—·—··	DRAINAGE DITCH
▨	CONCRETE
———	SUBSURFACE WATER INTERCEPTION TRENCH

ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION
ZIONSVILLE, INDIANA
SUBSURFACE WATER INTERCEPTION TRENCH

ERM ERM-North Central, Inc.

FIGURE NO. 3-1

7/19/89

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TABLE 3-2
COMPOUNDS DETECTED IN THE SOIL AT CONCENTRATIONS
ABOVE THE ACCEPTABLE SOIL CONCENTRATIONS (1)

Compound	Acceptable Soil Concentration (ug/kg)	Maximum Detected Concentration (ug/kg)
VOLATILE ORGANICS (VOCs):		
Acetone	490	650,000
Chloroform	2,300	2,900
1,1-Dichloroethane	5.7	35,000
1,1-Dichloroethene	120	380
Ethylbenzene	234,000	1,500,000
Methylene Chloride	20	310,000
Methyl Ethyl Ketone	75	2,800,000
Methyl Isobutyl Ketone	8,900	190,000
Tetrachloroethene	130	650,000
Toluene	238,000	2,000,000
1,1,1-Trichloroethane	7,200	1,100,000
1,1,2-Trichloroethane	22	550
Trichloroethene	240	4,800,000
Total Xylenes	195,000	6,800,000
BASE NEUTRAL/ACID ORGANICS:		
Phenol	9,800	570,000

(1) Acceptable Soil Concentrations are determined in accordance with Footnotes 5 and 6 of Table 3-1.

TABLE 3-3
CHEMICAL PROPERTIES OF ORGANIC COMPOUNDS
DETECTED IN THE SOILS AT CONCENTRATIONS
ABOVE THE ACCEPTABLE SOIL CONCENTRATIONS (1)

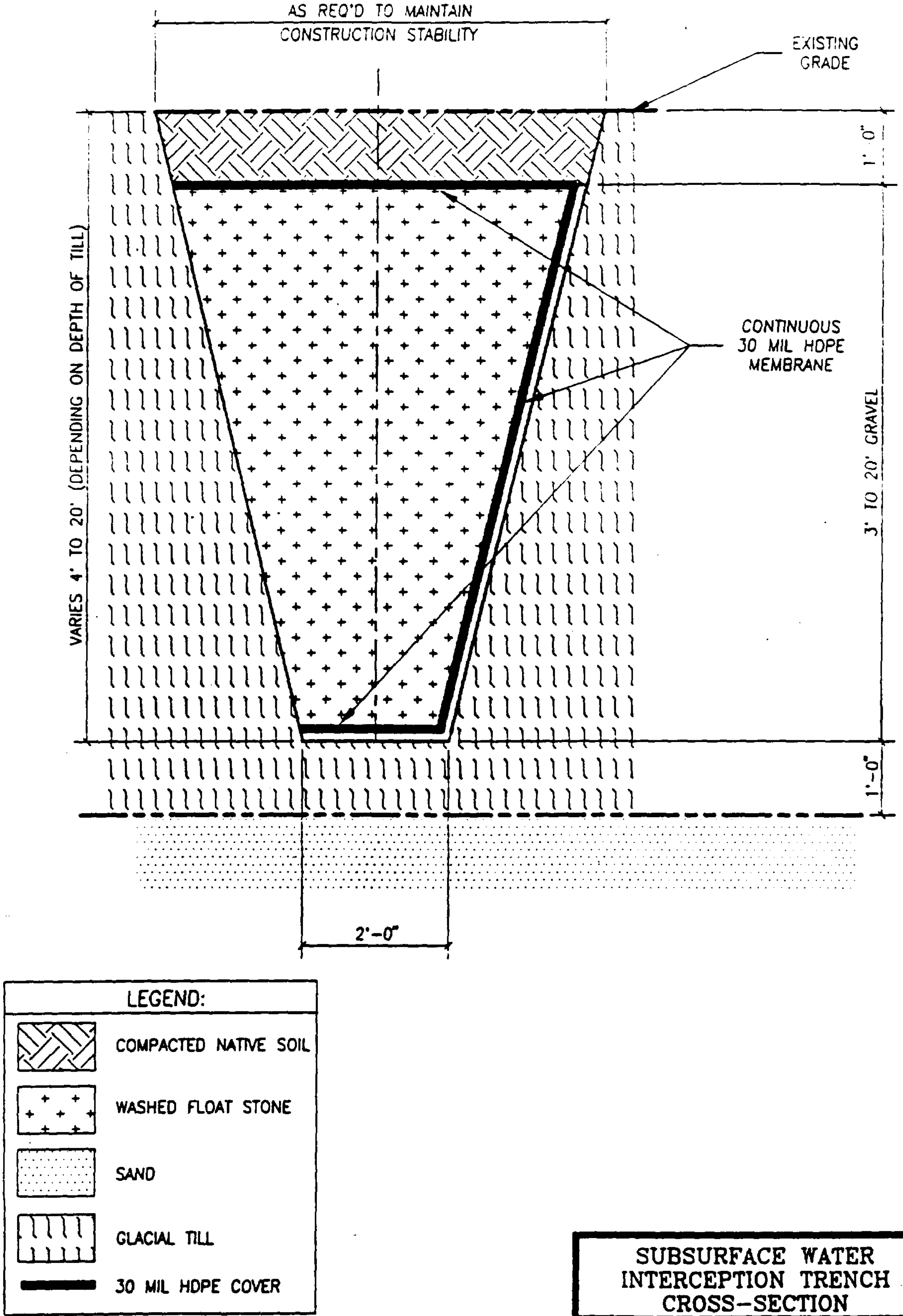
Compound	Solubility (ug/l)	Vapor Pressure (mm Hg)
VOLATILE ORGANICS (VOCs):		
Acetone	1,000,000,000	270
Chloroform	8,200,000	151
1,1-Dichloroethane	5,500,000	182
1,1-Dichloroethene	2,250,000	600
Ethylbenzene	152,000	7
Methylene Chloride	20,000,000	362
Methyl Ethyl Ketone	268,000,000	77.5
Methyl Isobutyl Ketone	17,000,000	6
Tetrachloroethene	200,000	17.8
Toluene	535,000	28.1
1,1,1-Trichloroethane	4,400,000	123
1,1,2-Trichloroethane	4,500,000	30
Trichloroethene	1,100,000	57.9
Total Xylenes	198,000	10
BASE NEUTRAL/ACID ORGANICS:		
Phenol	93,000,000	0.341

(1) Acceptable Soil Concentrations are determined in accordance with Footnotes 5 and 6 of Table 3-1.

REFERENCES:

U.S. EPA, "Superfund Public Health Evaluation Manual," 1986.

U.S. EPA, "Water-Related Environmental Fate of 129 Priority Pollutants," December 1979.



SUBSURFACE WATER INTERCEPTION TRENCH CROSS-SECTION	FIGURE 3-2
ERM-North Central, Inc.	6/23/89

intercepted in this trench to the Indianapolis POTW (via the NSL pipeline or tank truck), or provide other appropriate handling and treatment of such water in accordance with applicable Federal, State and local requirements.

- Subsurface water will continue to be removed and handled in this manner until "confirmed" analytical results from two consecutive, semi-annual subsurface water samples collected from the interception trench show that the Acceptable Stream Concentrations in Table 3-1 or Applicable Surface Water Background Concentrations have been met, unless the Parties to the Decree otherwise agree.

- Semi-annual monitoring of off-site wells and surface water will continue for five years after the Acceptable Stream Concentrations in Table 3-1 or Applicable Surface Water Background Concentrations have been achieved.

- If "confirmed" analytical results from two consecutive semi-annual samples collected during the 5 years of off-site monitoring in either the surface water or the wells indicate that the same parameter exceeds its Acceptable Stream Concentration or Applicable Surface Water Background Concentration at the same monitoring point, then subsurface water collection and treatment will be reinstituted.

As used in this section and in section 4.3 below, the term "confirmed" shall permit the Parties to demonstrate that an analytical result is not accurate as a result of errors in sampling, analysis, or evaluation or that it otherwise mischaracterizes the concentration of a parameter. The procedures used to obtain "confirmed" data shall include reanalysis, resampling and the analysis of only undiluted samples if a concentration is qualified with a "J" (estimated concentration). If after reanalysis and/or resampling using an undiluted sample the concentration of a compound is still qualified with a "J", then the result produced from undiluted samples will be used. "B" qualified samples results will be considered as "confirmed" data <u>only</u> if the concentrations in the sample exceed ten times the maximum amount detected in any blank for the media being analyzed.

4.0 REMEDIAL ACTION VERIFICATION AND COMPLIANCE MONITORING

The soil vapor extraction system described herein is designed to achieve the cleanup standards for VOCs as presented in Table 3-1 and phenol. The time required to accomplish this removal depends on the type of compound and soil, air flow rate and temperature, and on an efficient diffusion of air through the soil pores. The time required for treatment was estimated using a vapor extraction model, as described below and in Appendix C. Monitoring of vapor from the combined vapor stream and from individual trenches, as described below, will also be used to estimate completion of the soil vapor extraction system operation. Afterwards, verification of soil cleanup will be accomplished by: (1) soil vapor monitoring of restart spikes;

(2) on-site subsurface till water monitoring; and (3) soil sampling ("Soil Cleanup Verification").

Compliance monitoring will consist of sampling of surface water in Unnamed Ditch, and sampling of subsurface water in off-site till and sand and gravel monitoring wells and on-site till monitoring wells ("Compliance Monitoring").

4.1 Estimation of Completion of Vapor Extraction System Operation

A computer model which simulates the vapor extraction system was used to estimate the time required for removal of the maximum detected soil concentrations to the Acceptable Soil Concentrations specified in Table 3-1. Appendix C summarizes the characteristics of the model and the data used. Based on the model results, the Settling Defendants expect that after one year of operation, all the VOCs and phenol will be below the Acceptable Soil Concentrations in Table 3-1 in a "worst case" soil element which contains all the compounds at their maximum detected concentrations.

The vapor extraction system is designed to permit vapor samples to be obtained from each individual extraction trench and from the combined vapor stream from all operating extraction trenches.

The combined vapor flow will be sampled daily during the first week of operation, weekly for the following 4 weeks, and monthly thereafter. Samples will be analyzed for VOCs listed in Table 3-1 and phenol. Also, the vapor flow rate will be monitored and recorded to provide sufficient data to calculate the mass of organics removed from the soils and the effectiveness of the system. These data will also aid in estimating the treatment time remaining, based on the calculated mass extraction rate (lbs/day) of the VOCs listed in Table 3-1 and phenol.

Vapor samples from individual extraction trenches will be collected at the beginning of the vapor extraction system operation to establish a baseline of organics removal per trench. These samples will be analyzed for the VOCs listed in Table 3-1 and phenol. Once the mass rate extracted per day is reduced to 5 percent of the initial week's rate, additional vapor samples of individual trenches will be collected at least every two months, to determine when individual extraction trenches can be shut down. The criterion for shutting down individual trenches will be that two consecutive air samples from an individual trench show vapor concentrations to be in equilibrium with the Acceptable Soil Concentrations in Table 3-1. Table 4-1 shows the soil vapor concentrations in equilibrium with the Acceptable Soil Concentrations for the VOCs listed in Table 3-1 and phenol. Appendix D presents the methodology used to arrive at these equilibrium vapor concentrations.

4.2 Soil Cleanup Verification

Verification of soil cleanup will be established when each of the following is met: (1) the soil vapor from the restart spike tests shows compliance with the calculated soil vapor concentrations in equilibrium with Acceptable Soil Concentrations for the VOCs listed in Table 3-1 and phenol ("Soil Vapor Criterion"); (2) on-site till wells show compliance with the Acceptable Subsurface Water Concentrations specified in Table 3-1 or Applicable Subsurface Water Background Concentrations ("Onsite Till Water

TABLE 4-1
SOIL VAPOR CONCENTRATIONS IN EQUILIBRIUM
WITH ACCEPTABLE SOIL CONCENTRATIONS (1)

Compound (2)	Soil Vapor Concentration (3) (mg/l)	ppmv
VOLATILE ORGANICS (VOCs):		
Acetone	0.613	254
Chloroform	2.46	496
1,1-Dichloroethane	0.014	3.4
1,1-Dichloroethene	2.045	515
Ethylbenzene	37	9,316
Methylene Chloride	0.079	22.4
Methyl Ethyl Ketone	0.039	13
Methyl Isobutyl Ketone	0.685	233
Tetrachloroethene	0.116	16.8
Toluene	107	36,556
1,1,1-Trichloroethane	8.29	2,819
1,1,2-Trichloroethane	0.0060	1.1
Trichloroethene	0.39	71.5
Total Xylenes	26.2	4,794
BASE NEUTRAL/ACID ORGANICS:		
Phenol	0.0053	1.4

(1) Acceptable Soil Concentrations are determined in accordance with Footnotes 5 and 6 of Table 3-1.
(2) Compounds above acceptable soil concentrations in Table 3-1 to be removed by vapor extraction.
(3) From Appendix D.

Criterion"); and (3) soil samples show compliance with the Acceptable Soil Concentrations as specified in Table 3-1 ("Soil Sample Criterion"). If Soil Cleanup Verification is not established, vapor extraction will be restarted. If after five years from the initial commencement of soil vapor extraction (or sooner as permitted in the Decree), Soil Cleanup Verification has not been established, then the Additional Work provisions of Section VII of the Consent Decree will apply.

4.2.1 Soil Vapor Criterion

Once the combined vapor flow and individual trench vapor samples show concentrations of Table 3-1 VOCs and phenol at or below their respective equilibrium soil vapor concentrations shown in Table 4-1, the "restart spike" method on the combined vapor flow will be used to demonstrate that the Soil Vapor Criterion for Soil Cleanup Verification has been achieved.

The "restart spike" method consists of periodically shutting down and restarting the vapor extraction system. By shutting down the system, equilibrium conditions between the vapor space within the soil and any remaining organics amenable to vapor extraction within the soil matrix are re-established. Therefore, when the vapor extraction system is restarted, the initial organics concentration in the extracted gas will be higher than under normal operation.

The restart spike procedure will include shutting down the vapor extraction system for a period of three days. Upon restarting the vapor extraction system, all extraction and injection trenches will be operated as during normal operation. A sample of the combined soil vapor will be collected over a five-hour period starting 30 minutes after restarting the vapor extraction system. This sample will be representative of the soil vapor concentrations in equilibrium with the soil concentrations, because at 500 SCFM, the vapor extraction system will exchange one pore volume of soil every five hours.

The Soil Vapor Criterion will be met when analyses of soil vapor samples collected from four consecutive restart spikes conducted once every two weeks show that concentrations of VOCs and phenol in Table 3-1 are at or below equilibrium soil vapor concentrations shown in Table 4-1 and therefore by calculation can be shown to be at or below the Acceptable Soil Concentrations in Table 3-1.

4.2.2 On-site Till Water Criterion

Samples of the subsurface water from the on-site till monitoring wells will be collected quarterly during operating of the soil vapor extraction system. The most recent quarterly sampling results from the four on-site till water monitoring wells following demonstration that the Soil Vapor Criterion has been achieved (Section 4.2.1) will be used to demonstrate that the On-site Till Water Criterion for Soil Cleanup Verification has been achieved.

This criterion will be met when analyses of the water samples collected from each of the four on-site till wells show that the concentrations for parameters with Acceptable Subsurface Water Concentrations in Table 3-1 are at or below the Acceptable Subsurface Water Concentrations in Table 3-1 or Applicable Subsurface Water Background Concentrations.

4.2.3 Soil Sample Criterion

Once the Soil Vapor Criterion and Onsite Till Water Criterion for Soil Cleanup Verification have been demonstrated as defined above, a total of twenty (20) soil samples from areas selected by EPA and the State will be collected. These twenty (20) will be selected as follows: sixteen soil samples will be from "hot" spot areas and four non-background samples will be from randomly selected points elsewhere onsite. The total number of soil samples used to demonstrate that the Soil Sample Criterion for Soil Cleanup Verification will not exceed 20. Each soil sample will be analyzed for the VOCs in Table 3-1 and phenol. Verification of this criterion for all VOCs in Table 3-1 and phenol relative to the Acceptable Soil Concentration in Table 3-1. If the results from this initial round of soil samples verify that the Acceptable Soil Concentrations in Table 3-1 have been met, then the Soil Sample Criterion for Soil Cleanup Verification will have been achieved.

In the event that the soil sampling results do not verify that the Acceptable Soil Concentrations as defined in Table 3-1 have been met, and the soil vapor extraction system is operated for an additional period of time, an additional 20 soil samples must be taken in the same approximate locations (i.e., within a 3-foot radius) as the initial sample locations. Results from this second sampling will be analyzed using the identical procedure outlined above to verify that the Acceptable Soil Concentrations in Table 3-1 as described in Footnote 6 of Table 3-1 have been met. If the results from any subsequent round of soil samples demonstrate that the Acceptable Soil Concentrations in Table 3-1 have been met, then the Soil Sample Criterion for Soil Cleanup Verification will have been achieved.

4.3 Post Soil Cleanup Compliance Monitoring

Once Soil Cleanup Verification has been achieved as prescribed in Section 4.2, sampling of off-site till wells, on-site till wells, off-site sand and gravel wells and surface water will be conducted for seven years on a semi-annual basis.

Off-site wells and surface water will be analyzed for the parameters with Acceptable Stream Concentrations in Table 3-1. Onsite wells will be analyzed for parameters with Acceptable Subsurface Water Concentrations in Table 3-1.

If "confirmed" analytical results from two consecutive semi-annual samples collected during the Compliance Monitoring period indicate that the same parameter exceeds its Cleanup Standard (or the Applicable Surface Water or Subsurface Water Background Concentration) at the same monitoring point, then the Additional Work provisions of Section VII of the Decree will apply. If the conditions set forth in the preceding sentence do not occur, monitoring will be discontinued at the end of the Compliance Monitoring period and the provisions of Section XXVI of the Decree will apply.

5.0 MISCELLANEOUS PROVISIONS AND SCHEDULING

The following documents have been submitted to EPA and the State for review and approval by EPA: (1) Health and Safety Plan, (2) Field Sampling Plan, and (3) Quality Assurance Project Plan. Construction drawings and contract specifications will be submitted to EPA and the State within three months from the entry of the Consent Decree. Comments provided by EPA and the State will be addressed by the Settling Defendants.

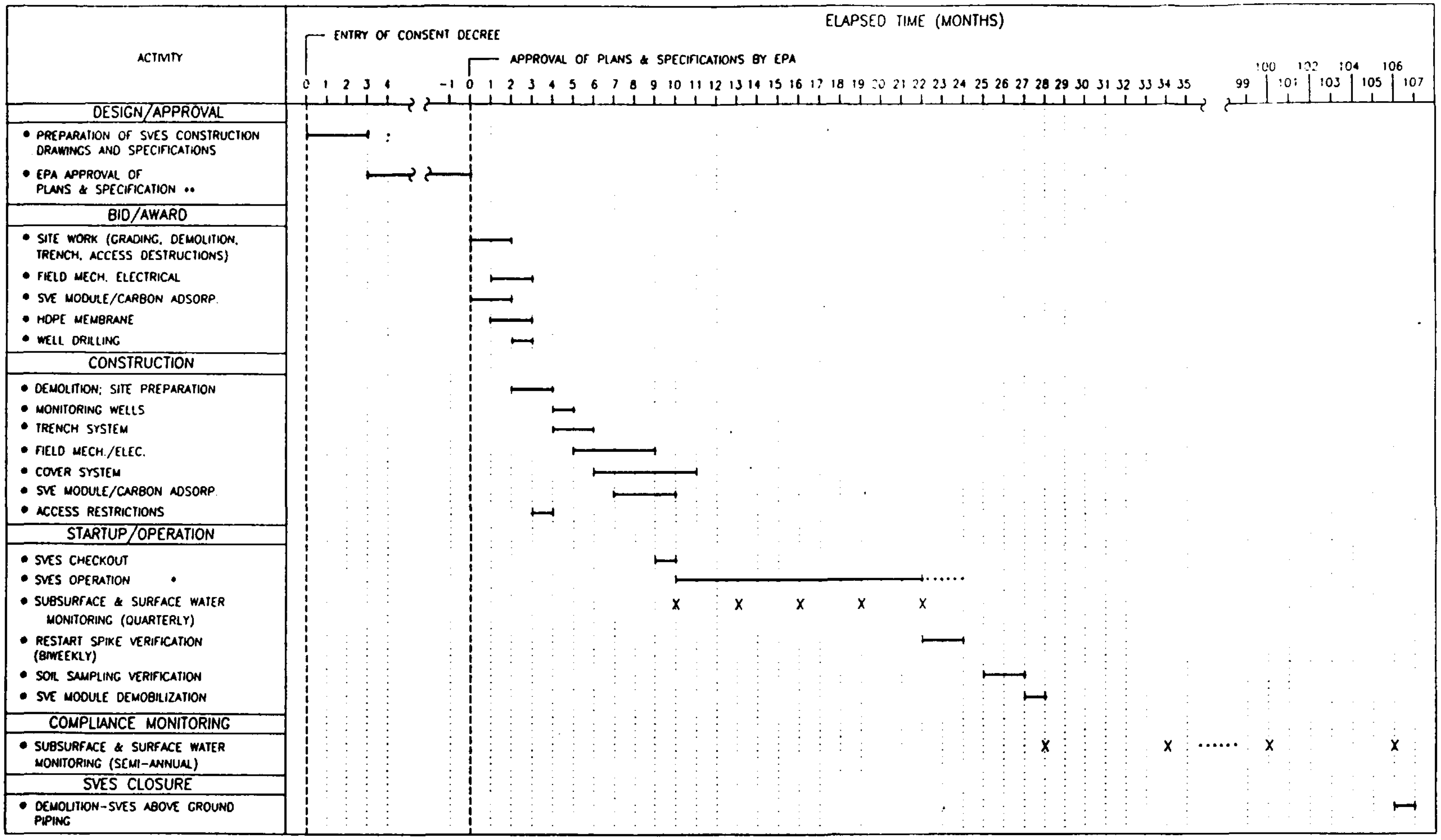
Figure 5-1 sets forth the Remedial Action Implementation Schedule for implementing the remedy required under the Consent Decree. The following milestones have been established in Section XVII (Stipulated Penalties) of the Consent Decree:

- o Submission of the project plans, construction contract specifications and revised drawings necessary to solicit competitive bidding within 3 months from the entry of the Decree.

- o Completion of site preparation, including grading, removal of the tanks and buildings, repair or moving of the fence, 4 months after approval by EPA all of the above referenced documents. Completion of the site preparation shall mean that all hindrances, obstructions or obstacles to construction and security of the soil vapor extraction trenches, monitoring wells or cap have been removed.

- o Completion of installation of the on-site and off-site monitoring wells 5 months after approval by EPA of all of the above referenced documents.

- o Startup of the soil vapor extraction system 10 months after approval by EPA of all of the above referenced documents.



NOTES TO FIGURE 5-1

- SVES ≙ SOIL VAPOR EXTRACTION SYSTEM
- SCHEDULE ASSUMES 12 MONTH OPERATION OF SVES. ACTUAL PERIOD OF OPERATION COULD BE SHORTER OR LONGER DEPENDING ON PERFORMANCE OF SVES. THE SCHEDULE FOR EACH ACTIVITY LISTED BELOW "SVES OPERATION" WILL BE ADJUSTED ACCORDINGLY AS DESCRIBED IN SECTION 4.0 OF EXHIBIT A.

•• "PLANS AND SPECIFICATIONS" MEANS "PROJECT PLANS, CONSTRUCTION CONTRACT SPECIFICATIONS, AND REVISED DRAWINGS NECESSARY TO SOLICIT COMPETITIVE BIDDING."

REMEDIAL ACTION IMPLEMENTATION SCHEDULE	FIGURE NO. 5-1
ERM ERM-North Central, Inc.	9/18/89 CA

- Completion of the installation of all components of the RCRA-compliant (Subtitle C) cover 11 months after approval by EPA of all of the above referenced documents.

- Submission of all documents necessary to perform Additional Work that may be required under Section VII of the Consent Decree 6 months after written notice has been provided by EPA or Settling Defendants that Additional Work needs to be implemented.

- Completion of installation of the subsurface water interception trench on a schedule to be determined by EPA after consultation with the State.

APPENDICES

APPENDIX A

ESTIMATE OF MASS OF ORGANICS IN THE SOILS
TO BE REMOVED BY VAPOR EXTRACTION

APPENDIX A
ESTIMATE OF MASS OF ORGANICS IN THE SOILS
TO BE REMOVED BY VAPOR EXTRACTION

Location	Sampling depth (ft)	Assumed contamination depth (ft)	Total concentration (ug/kg)	Mass (lb)
TP-1	1 - 1.5	2	1,972	0.271
TP-2	1 - 1.5	2	28	0.004
TP-3	1 - 1.5	2	108,800	14.978
TP-4	1 - 2	2.5	99,730	17.162
TP-4	2.5 - 3.5	4	4,416	1.216
TP-5	1 - 2	2	24,287	3.343
TP-5	2 - 3	1.5	291	0.030
TP-6	1 - 2	2	12,468,000	1,716.410
TP-6	2 - 3	1.5	22,690	2.343
TP-6	4 - 5	1.5	2,416	0.249
TP-7	1 - 2.5	2.5	267,000	45.946
TP-7	2.5 - 4	2	280,090	38.559
TP-8	1 - 2.5	2.5	3,687	0.634
TP-8	2.5 - 4	2	433,600	59.692
TP-9	1 - 3	3	14,604,000	3,015.694
TP-9	3 - 5	2.5	130	0.022
TP-10	1 - 3	3	958	0.198
TP-10	3 - 5	2.5	432	0.074
TP-11	1 - 3	3	130	0.027
TP-11	3 - 5	2.5	67	0.012
TP-12	1 - 3	3	35,030	7.234
TP-12	3 - 5	2.5	3,609	0.621
SB-01	2.5 - 4	3	3,303	0.682
SB-02	2.5 - 4	3	12,900	2.664
SB-03	2.5 - 4	3	70,070	14.469
SB-04	2 - 3.5	2.5	175	0.030
SB-06	2 - 3.5	2.5	222,010	38.204
SB-08	2.5 - 4	3	3,012	0.622
SB-09	2.5 - 4	3	61,490	12.698
SB-01	5.5 - 7	2	27	0.004
SB-02	5.5 - 7	2	34	0.005
SB-04	5 - 6.5	2	51	0.007
SB-08	7 - 8.5	2	188	0.026
SB-09	5.7 - 7	2	8,069	1.111
TOTAL ORGANICS TO BE REMOVED BY VAPOR EXTRACTION, lb				4,995

* The area contaminated is assumed to be a 25'x25' square around each sampling location. TP = test pit; SB = soil boring. Soil concentrations from ECC RI, Section 4.

APPENDIX B

CALCULATION OF RISK-BASED CLEANUP STANDARDS

APPENDIX B

CALCULATION OF RISK-BASED CLEANUP STANDARDS

The equations used to calculate risk-based concentrations are shown in Table B1. The ingestion rates and acceptable risks are listed in Table B2. The potency factors and references doses for compounds without any regulatory or background level are from a memorandum from the USEPA Toxics Integration Branch, OERR, Washington, D.C., dated December 19, 1988, with the Corrections to the July, 1988 Update of the Characterization Tables in the Superfund Public Health Evaluation Manual.

Table B3 presents the calculation of risk-based acceptable subsurface water concentrations in the till for compounds without a regulatory limit (drinking water Maximum Contaminant Level, Maximum Contaminant Level Goal or lifetime health advisory or a stream criterion as listed in Table 1 of the Record of Decision for the site). Table B4 shows that the resulting concentrations of inorganic compounds at Unnamed Ditch should be below the Stream Criteria presented in Table 1 of the Record of Decision (ROD) for the site, dated September 25, 1987. The dilution obtained from discharge of the subsurface water in the till to Unnamed Ditch is 1:1800, as presented in Appendix C of the ECC Remedial Investigation. Note that most of the calculated concentrations in the ditch are below detection limits.

Tables B5 and B6 list the acceptable risk-based soil concentrations, based on soil and subsurface water ingestion, respectively. The calculation of acceptable soil concentrations based on subsurface water ingestion follows the procedures presented in Appendix C of the ECC RI. Only those organic compounds without regulatory limit (USEPA, Polychlorinated

TABLE B1

EQUATIONS USED TO CALCULATE RISK-BASED CONCENTRATIONS *

SOIL (concentrations in ug/kg):

$$\frac{\text{Risk} * \text{Body Weight (kg)} * 1000\ \text{(ug/mg)} * 1000\ \text{(g/kg)}}{\text{Ingestion rate (g/d)} * \text{Potency Factor (mg/kg/d)-1}}$$

or

$$\frac{\text{Risk} * \text{Body Weight (kg)} * \text{Reference Dose (mg/kg/d)} * 1000\ \text{(ug/mg)} * 1000\ \text{(g/kg)}}{\text{Ingestion rate (g/d)}}$$

SUBSURFACE WATER (concentrations in ug/l):

$$\frac{\text{Risk} * \text{Body Weight (kg)} * 1000\ \text{(ug/mg)}}{\text{Ingestion rate (l/d)} * \text{Potency Factor (mg/kg/d)-1}}$$

or

$$\frac{\text{Risk} * \text{Body Weight (kg)} * \text{Reference Dose (mg/kg/d)} * 1000\ \text{(ug/mg)}}{\text{Ingestion rate (l/d)}}$$

TABLE B2

INGESTION RATES AND ACCEPTABLE RISKS

INGESTION RATES * :

SOILS:

0.1 grams per day by a 70-kilogram person for 70 years

or

0.2 grams per day by a 17-kilogram child for 5 years

SUBSURFACE WATER:

2 liters of water per day by a 70-kilogram person for 70 years

ACCEPTABLE RISKS:

COMPOUNDS WITH POTENCY FACTORS:

10^{-6}

COMPOUNDS WITH REFERENCE DOSES:

1

* From U.S. EPA, RCRA Facility Investigation Guidance, 1987, and U.S. EPA, Office of Solid Waste and Emergency Response, Memorandum on Interim Final Guidance for Soil Ingestion Rates, January 27, 1989.

TABLE B3
ECC - ACCEPTABLE HEALTH-BASED SUBSURFACE WATER CONCENTRATIONS

Compound (1)	Potency Factor (2) (mg/kg/d)-1	Reference Dose (2) (mg/kg/d)	Acceptable Health-Based Subsurface Water Concentration (3) (ug/l)
VOLATILE ORGANICS (VOCs):			
Acetone		0.1	3,500
1,1-Dichloroethane	0.091		0.38
Methylene Chloride	0.0075		4.7
Methyl Isobutyl Ketone		0.05	1,750
Tetrachloroethene	0.051		0.69
1,1,2-Trichloroethane	0.057		0.61
BASE NEUTRAL/ACID ORGANICS:			
Bis(2-ethylhexyl)phthalate	0.014		2.5
Di-n-Butyl Phthalate		0.1	3,500
Diethyl Phthalate		0.8	28,000
Isophorone	0.0041		8.5
Naphthalene		0.4	14,000
Phenol		0.04	1,400
PESTICIDES/PCBs:			
Aroclor-1232	7.7		0.0045
Aroclor-1260	7.7		0.0045
INORGANICS:			
Antimony		0.0004	14
Beryllium		0.005	175
Manganese		0.2	7,000
Tin		0.6	21,000
Vanadium		0.007	245
Zinc		0.2	7,000

(1) Only compounds without a regulatory limit (drinking water Maximum Contaminant Level [40 CFR 141], Maximum Contaminant Level Goal or lifetime health advisory) are shown.

(2) From USEPA Toxics Integration Branch, OERR, Washington, D.C. December 1988 correction to the July 1988 Update of the Risk Characterization Tables in the Superfund Public Health Evaluation Manual.

(3) Acceptable subsurface water concentrations calculated using an ingestion rate of 2 liters per day by a 70 kg adult for 70 years. Acceptable risk = 1E-06 for compounds with potency factor and 1 for compounds with reference dose.

TABLE B4
COMPARISON OF ACCEPTABLE STREAM CONCENTRATIONS
WITH STREAM CONCENTRATIONS BASED ON NATURAL
DISCHARGE OF SUBSURFACE WATER FROM THE TILL

Compounds (1)	Acceptable Stream Concentration (1) (ug/l)	Concentratio Unnamed Ditc to Discharge o Water at Accep Concentration (ug/l)
VOLATILE ORGANICS (VOCs):		
Chloroform	15.7	0.056
1,1-Dichloroethene	1.85	0.0039
Ethylbenzene	3,280	1.9
Methylene Chloride	15.7	0.0026
Tetrachloroethene	8.85	0.00038
Toluene	3,400	5.8
1,1,1-Trichloroethane	5,280	0.11
1,1,2-Trichloroethane	41.8	0.00034
Trichloroethene	80.7	0.0028
BASE NEUTRAL/ACID ORGANICS:		
Bis(2-ethylhexyl)phthalate	50,000	0.0014
Di-n-Butyl Phthalate	154,000	1.9
Diethyl Phthalate	52,100	15.6
Naphthalene	620	7.8
Phenol	570	0.78
INORGANICS:		
Arsenic	0.0175	0.028
Chromium	11	0.028
Lead	10	0.028
Nickel	100	0.39
Zinc	47	3.9
Cyanide	5.2	0.39

(1) From Table 1 of the Record of Decision (ROD) for the site, September 25, 1987. Only those compounds detected in ECC soil samples that are listed in this table are shown.
(2) Assuming a dilution of 1:1800 for natural discharge of till water at acceptable concentrations into Unnamed Ditch (from EC Remedial Investigation, Appendix C).

TABLE B5

ECC - ACCEPTABLE SOIL CONCENTRATIONS BASED ON SOIL INGESTION

Compounds (1)	Potency Factor (2) (mg/kg/d)-1	Reference Dose (2) (mg/kg/d)	Acceptable Soil Concentrations Based on Soil Ingestion (3) (ug/kg)	Range of Acceptable Soil Concentrations Based on Soil Ingestion (4) (ug/kg)
VOLATILE ORGANICS (VOCs):				
Acetone		0.1	8,500,000	8,500,000
Chlorobenzene		0.03	2,550,000	2,550,000
Chloroform	0.0061		114,754	11,475-11,475,400
1,1-Dichloroethane	0.091		7,692	769-769,200
1,1-Dichloroethene	0.6		1,167	116.7-116,700
Ethylbenzene		0.1	8,500,000	8,500,000
Methylene Chloride	0.0075		93,333	9,333-9,333,300
Methyl Ethyl Ketone		0.05	4,250,000	4,250,000
Methyl Isobutyl Ketone		0.05	4,250,000	4,250,000
Tetrachloroethene	0.051		13,725	1,373-1,372,500
Toluene		0.3	25,500,000	25,500,000
1,1,1-Trichloroethane		0.09	7,650,000	7,650,000
1,1,2-Trichloroethane	0.057		12,281	1,228-1,228,100
Trichloroethene	0.011		63,636	6,364-6,363,600
Total Xylenes		2	170,000,000	170,000,000
BASE NEUTRAL/ACID ORGANICS:				
Bis(2-ethylhexyl)phthalate	0.014		50,000	5,000-5,000,000
Di-n-Butyl Phthalate		0.1	8,500,000	8,500,000
Diethyl Phthalate		0.8	68,000,000	68,000,000
Isophorone	0.0041		170,732	17,073-17,073,200
Naphthalene		0.4	34,000,000	34,000,000
Phenol		0.04	3,400,000	3,400,000

NOTES:

(1) Only organic compounds without a regulatory limit in soils (USEPA, "Polychlorinated Biphenyls Spill Cleanup Policy Rule," 40 CFR Part 761) are shown.

(2) From USEPA Toxics Integration Branch, OERR, Washington, D.C. December 19, 1988, "Corrections to the July 1988 Update of the Characterization Tables in the Superfund Public Health Evaluation Manual."

(3) Intake for compounds with potency factor: 0.1 g of soil/d by 70 kg resident adults. Intake for compounds with reference dose: 0.2 g of soil/d by 17 kg resident children. Acceptable risks: 1E-06 for compounds with potency factor; 1 for compounds with reference dose.

(4) Range shown is for risks of 10-4 to 10-7 for compounds with potency factor. The value shown for compounds without potency factor is for a risk of 1.

TABLE B6 (Page 1 of 2)

ECC - ACCEPTABLE SOIL CONCENTRATIONS BASED ON THEORETICAL SUBSURFACE WATER INGESTION AT THE SITE (10-6 RISK)

Compound (1)	Solubility (2) (ug/l)	Log Kow (2)	Kd (3)	Acceptable Subsurface Water Concentration (4) (ug/l)		Acceptable Leachate Concentration (5) (ug/l)	Acceptable Soil Concentration Based on Water Ingestion (6) (ug/kg)
VOLATILE ORGANICS (VOCs):							
Acetone	1,000,000,000	-0.24	0.00071	3,500	RB	686,275	490
Chlorobenzene	466,000	2.84	0.858	60	MCLGP	11,765	10,093
Chloroform	8,200,000	1.97	0.116	100	MCL	19,608	2,269
1,1-Dichloroethane	5,500,000	1.79	0.076	0.38	RB	74.5	5.7
1,1-Dichloroethene	2,250,000	1.84	0.086	7	MCL	1,373	118
Ethylbenzene	152,000	3.15	1.75	680	MCLGP	133,333	233,540
Methylene Chloride	20,000,000	1.25	0.022	4.7	RB	922	20.3
Methyl Ethyl Ketone	268,000,000	0.26	0.00226	170	LDWHA	33,333	75
Methyl Isobutyl Ketone	17,000,000		0.02604	1,750	RB	343,137	8,935
Tetrachloroethene	200,000	2.88	0.941	0.69	RB	135	127
Toluene	535,000	2.69	0.607	2,000	MCLGP	392,157	238,167
1,1,1-Trichloroethane	4,400,000	2.17	0.183	200	MCL	39,216	7,193
1,1,2-Trichloroethane	4,500,000	2.17	0.183	0.61	RB	120	21.9
Trichloroethene	1,100,000	2.29	0.242	5	MCL	980	237
Total Xylenes	198,000	3.26	2.26	440	MCLGP	86,275	194,672
BASE NEUTRAL/ACID ORGANICS:							
Bis(2-ethylhexyl)phthalate	1,300	8.7	621472	2.5	RB	490	304,643,220
Di-n-Butyl Phthalate	13,000	5.2	197	3,500	RB	686,275	134,871,303
Diethyl Phthalate	4,320,000	3.22	2.06	28,000	RB	5,490,196	11,298,207
Isophorone	12,000		0.031	8.5	RB	1,667	51.7
Naphthalene	30,000	3.01	1.269	14,000	RB	2,745,098	3,483,209
Phenol	93,000,000	1.46	0.036	1,400	RB	274,510	9,817

TABLE B6 (Page 2 of 2)

ECC - ACCEPTABLE SOIL CONCENTRATIONS BASED ON THEORETICAL SUBSURFACE WATER INGESTION AT THE SITE (10-6 RISK)

(1) Only organic compounds without a regulatory limit in soils (USEPA, "Polychlorinated Biphenyls Spill Cleanup Policy Rule," 40 CFR Part 761) are shown.

(2) From ECC RI, Table 5-3, and Verschueren, 1983, "Handbook of Environmental Data on Organic Chemicals".

(3) From ECC RI, Table 5-3. Calculated as 10^log Kow * OC, where OC= organic carbon content = 0.00124. For isophorone and methyl isobutyl ketone, the Kd is obtained as Kd = Koc * OC, where Koc = organic carbon-water partition coefficient, obtained from log Koc = (-0.55 * log S) + 3.64 (Exhibit A-1 of "Superfund Public Health Evaluation Manual," 1986).

(4) RB = risk-based concentration, from Table B3; MCL = Maximum Contaminant Level, from 40 CFR 141; MCLGP = proposed MCL goal, from 40 CFR 141; LDWHA = lifetime drinking water health advisory, from "Superfund Public Health Evaluation Manual," 1986.

(5) Leachate discharge/subsurface water discharge = 0.0051 (Appendix C of the ECC RI; and reduction of the 7.8 in/yr recharge used in the RI under the current conditions [page 5-8] by 99 percent due to the cap).

(6) Soil concentration (ug/kg) = Kd * Concentration in leachate (ug/l).

Biphenyls Spill Cleanup Police Rule, 40 CFR Part 761) in soils are listed in Tables B5 and B6. It is conservatively assumed that the volume of leachate from the soils will be reduced by 99 percent from the 7.8 in/yr used in the RI, by installing the RCRA-compliant (Subtitle C) cover over the site.

A range of acceptable soil concentrations based on water ingestion using the published ranges for organic carbon content of till soils and the SARA range of risk for Superfund site cleanups, is presented in Table B7. A list of organic carbon content in soil is shown in Table B8, with the respective reference. The concentrations shown in Table B6 were used to determine the Acceptable Soil Concentrations specified in Table 3-1, using a risk of 10^{-6} and a soil organic carbon content of 0.12%, as presented in the RI. This soil organic carbon content was deemed conservative when compared to the values shown in Table B8.

Table B9 lists the solubility and vapor pressure of the organic compounds detected in the soils above the limits shown in Tables B5 and B6. All compounds, except bis(2-ethylhexyl)phthalate and Aroclor-1260, are amenable to removal by soil vapor extraction.

Finally, Table B10 presents the complete list of references used for the calculation of the Acceptable Soil Concentrations specified in Table 3-1.

TABLE B7

ECC - ACCEPTABLE SOIL CONCENTRATIONS BASED ON THEORETICAL SUBSURFACE WATER INGESTION AT THE SITE (RANGE OF RISKS)

Compound (1)	Range of Kd (2)	Acceptable Soil Concentration Based on Water Ingestion (3)		
		Range for 10-4 risk	Range for 10-7 risk	
VOLATILE ORGANICS (VOCs):				
Acetone	0.000058-0.0044	40-3,019	40-3,019	(4)
Chlorobenzene	0.069-5.24	814-61,600	814-61,600	(5)
Chloroform	0.0093-0.71	182-13,900	182-13,900	(5)
1,1-Dichloroethane	0.0062-0.47	46-3,500	0.046-3.50	
1,1-Dichloroethene	0.0069-0.52	9.47-714	9.47-714	(5)
Ethylbenzene	0.14-10.7	18,800-1,431,000	18,800-1,431,000	(5)
Methylene Chloride	0.0018-0.14	166-12,900	0.166-12.9	
Methyl Ethyl Ketone	0.00018-0.014	6.07-461	6.07-461	(5)
Methyl Isobutyl Ketone	0.0021-0.16	721-54,900	721-54,900	(4)
Tetrachloroethene	0.076-5.78	1,028-78,200	1.03-78.2	
Toluene	0.049-3.72	19,200-1,460,000	19,200-1,460,000	(5)
1,1,1-Trichloroethane	0.015-1.14	588-44,700	588-44,700	(5)
1,1,2-Trichloroethane	0.015-1.14	179-13,600	0.179-13.6	
Trichloroethene	0.020-1.52	19.6-1,490	19.6-1,490	(5)
Total Xylenes	0.18-13.7	15,700-1,193,000	15,700-1,193,000	(5)
BASE NEUTRAL/ACID ORGANICS:				
Bis(2-ethylhexyl)phthalate	50100-3810000	2,460,000,000-187,000,000,000	2,460,000-187,000,000	
Di-n-Butyl Phthalate	15.8-1200	10,800,000-824,000,000	10,800,000-824,000,000	(4)
Diethyl Phthalate	0.17-12.9	933,000-70,800,000	933,000-70,800,000	(4)
Isophorone	0.0025-0.19	417-31,700	0.417-31.7	
Naphthalene	0.1-7.6	275,000-20,900,000	275,000-20,900,000	(4)
Phenol	0.0029-0.22	796-60,400	796-60,400	(4)

NOTES:

(1) Only organic compounds without a regulatory limit in soils (USEPA, "Polychlorinated Biphenyls Spill Cleanup Policy Rule," 40 CFR Part 761) are shown.

(2) For a range of organic carbon content of 0.0001 to 0.0076 obtained from: U.S. Department of Agriculture, "Soil Classification - A Comprehensive System". Soil Conservation Service, 7th Approximation, 1960. Calculated as presented in Table B6.

(3) Acceptable Soil Concentrations at the risk shown (for compounds with potency) for a range of organic carbon content of 0.0001 to 0.0076. Calculated as presented in Table B6.

(4) Acceptable Soil Concentration range does not change because the compound does not have a potency factor.

(5) Acceptable Soil Concentration range does not change because the value is based on regulatory limits (drinking water Maximum Contaminant Level, Maximum Contaminant Level Goal, or lifetime health advisory).

TABLE B8 (Page 1 of 5)
ORGANIC CARBON CONTENT OF SOILS - REFERENCES

Organic Carbon Content, %	Type of Soil (depth)	Geographic Area	Reference
0.125 (avg over 1.5 acre site)	Loamy sand (4 ft)	Etiwanda, CA (arid region)	Elabd, H., and W.A. Jury. 1986. "Spatial variability of Pesticide Adsorption Parameters." Environmental Science and Technology, Vol. 20, No. 3, pp. 256-260.
0.2 (avg over 1.5 acre site)	Loamy sand (2 and 3 ft)	Ibid	Ibid
0.26 (avg over 1.5 acre site)	Loamy sand (1 ft)	· Ibid	Ibid
1.9	Silt loam	Corvallis, OR	Chiou, C.T., P.E. Porter, and D.W. Schmeddign. 1983. "Partition Equilibria of Nonionic Organic Compounds between Soil Organic Matter and Water." Environmental Science and Technology, Vol. 17, No. 4, pp. 227-231.
0.15	Sand close to river	Switzerland	Schwarzenbach, R.P., and J. Westall. 1981. "Transport of Nonpolar Organic Compounds from Surface Water to Groundwater. Laboratory Sorption Studies." Environmental Science and Technology, Vol. 15, No. 11, pp. 1360-1367.
2.1	Air-dried soil	Iowa	Wu, S., and P.M. Gschwend. 1986. "Sorption Kinetics of Hydrophobic Organic Compounds to Natural Sediments and Soils." Environmental Science and Technology, Vol. 20, No. 7, pp. 717-725.
0.11	Loess sample	Turin, Iowa	Karickhoff, S.W. 1984. "Organic Pollutant Sorption in Aquatic Systems." Journal of Hydraulic Engineering, Vol. 110, No. 6, pp. 707-735.
1.3	Soil	Fern Clyffe State Park, IL	Ibid
0.02	Aquifer -- water table zone 98 % sand	Borden, Canada	Abdul, A.S., T.L. Gibson, and D.N. Rai. 1986. "The Effect of Organic Carbon on the Adsorption of Fluorene by Aquifer Materials." Hazardous Waste and Hazardous Materials. Vol. 3, No. 4, pp. 429-440.
0.52	Aquifer -- water table zone 87 % sand	Flint, MI	Ibid
1.8	Aquifer -- water table zone 91 % sand	Flint, MI	Ibid

TABLE B8 (Page 2 of 5)
ORGANIC CARBON CONTENT OF SOILS - REFERENCES

Organic Carbon Content, %	Type of Soil (depth)	Geographic Area	Reference
0.05	Fine-sand soil	Wilmington, DE	Stokman, S.K. 1987. "Estimates of Concentrations of Soluble Petroleum Hydrocarbons Migrating into Ground Water from Contaminated Soil Sources." Proceedings of the National Water Well Association/American Petroleum Institute Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water - Prevention, Detection and Restoration. Houston, TX, pp. 541-558.
0.1	Shaly-silt soil	Philadelphia, PA	Ibid
0.05	Fine to coarse sand, 96% sand	Michigan	Chiang, C.Y., C.L. Klein, J.P. Salanitro, and H.L. Wisniewski. 1986. "Data Analyses and Computer Modelling of the Benzene Plume in an Aquifer Beneath a Gas Plant." Proceedings of the National Water Well Association/American Petroleum Institute Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water - Prevention, Detection and Restoration. Houston, TX, pp. 157-176.
0.27	Lincoln fine sand (surface soil)	Little Sandy Creek near Ada, OK	Clark, G.L., A.T. Kan, and M.B. Tomson. 1986. "Kinetic Interaction of Neutral Trace Level Organic Compounds with Soil Organic Material." Proceedings of the National Water Well Association/American Petroleum Institute Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water - Prevention, Detection and Restoration. Houston, TX, pp. 151-156.
0.74	Fine to medium grained sand (3 ft)	Indian River County, FL	Kemblowski, M.W., J.P. Salinatro, G.M. Deeley, and C.C. Stanley. 1987. "Fate and Transport of Residual Hydrocarbon in Groundwater - A Case Study." Proceedings of the National Water Well Association/American Petroleum Institute Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water - Prevention, Detection and Restoration. Houston, TX, pp. 207-231.
0.44	Fine to medium grained sand (7 ft)	Indian River County, FL	Ibid
0.12	Fine to medium grained sand (13 ft)	Indian River County, FL	Ibid

ORGANIC CARBON CONTENT OF SOILS - REFERENCES

Organic Carbon Content, %	Type of Soil (depth)	Geographic Area	Reference
0.36	Fine to medium grained sand (3 ft)	Indian River County, FL	Ibid
0.15	Fine to medium grained sand (13 ft)	Indian River County, FL	Ibid
1.08	Fine to medium grained sand (2 ft)	Indian River County, FL	Ibid
0.16	Fine to medium grained sand (11 ft)	Indian River County, FL	Ibid
0.72	Fine to medium grained sand (3 ft)	Indian River County, FL	Ibid
0.26	Fine to medium grained sand (10 ft)	Indian River County, FL	Ibid
0.74	Glacial till (1-2 ft)	Sargent County, ND	"Soil Classification - A Comprehensive System." 1960. U.S. Department of Agriculture, Soil Conservation Service, 7th Approximation.
0.33	Glacial till (2-3 ft)	Sargent County, ND	Ibid
0.18	Glacial till (4.5-5 ft)	Sargent County, ND	Ibid
0.1	Till (1-2 ft)	Strafford County, New Hampshire	Ibid
0.08	Till (2-3 ft)	Strafford County, New Hampshire	Ibid
0.03	Till (4-5 ft)	Strafford County, New Hampshire	Ibid
0.01	Till (5-7 ft)	Strafford County, New Hampshire	Ibid

TABLE B8 (Page 4 of 5)
ORGANIC CARBON CONTENT OF SOILS - REFERENCE

Organic Carbon Content, %	Type of Soil (depth)	Geographic Area	
0.59	Calcareous, glacial till (1-2 ft)	Greenbrier County, West Virginia	
0.27	Calcareous, glacial till (2-3 ft)	Greenbrier County, West Virginia	
0.08	Calcareous, glacial till (4-5 ft)	Greenbrier County, West Virginia	
0.38	Calcareous, glacial till (1-2 ft)	Tomkins County, New York	
0.16	Calcareous, glacial till (2-3 ft)	Tomkins County, New York	
0.17	Calcareous, glacial till (4.5-6.5 ft)	Tomkins County, New York	
0.14	Calcareous, glacial till (6.5-7 ft)	Tomkins County, New York	
0.76	Glacial till (1-2 ft)	Waseca County, Minnesota	
0.3	Glacial till (2-3 ft)	Waseca County, Minnesota	
0.19	Glacial till (> 4 ft)	Waseca County, Minnesota	
0.51	Glacial till (1-2 ft)	Sargent County, ND	
0.18	Glacial till (2-3 ft)	Sargent County, ND	
0.16	Glacial till (3.5-5 ft)	Sargent County, ND	

TABLE B8 (Page 5 of 5)
ORGANIC CARBON CONTENT OF SOILS - REFERENCES

Organic Carbon Content, %	Type of Soil (depth)	Geographic Area	Reference
0.64	Firm, glacial till (1-2 ft)	Spink County, SD	Ibid
0.36	Firm, glacial till (2-3 ft)	Spink County, SD	Ibid
0.31	Firm, glacial till (4-5 ft)	Spink County, SD	Ibid
0.46	Glacial till (1-2 ft)	Renville County, ND	Ibid
0.24	Glacial till (2-3 ft)	Renville County, ND	Ibid
0.13	Glacial till (4-5 ft)	Renville County, ND	Ibid
0.25	Glacial till (2-3 ft)	Adair County, Iowa	Ibid
0.08	Glacial till (> 6 ft)	Adair County, Iowa	Ibid
0.74	Calcareous, glacial till (1-2 ft)	Ward County, ND	Ibid
0.2	Calcareous, glacial till (2-3 ft)	Ward County, ND	Ibid
0.19	Calcareous, glacial till (4-5 ft)	Ward County, ND	Ibid
0.35	Glacial till (1-2 ft)	Cayuga County, NY	Ibid
0.1	Glacial till (2-3 ft)	Cayuga County, NY	Ibid
0.12	Glacial till (6-7 ft)	Cayuga County, NY	Ibid

TABLE B9
CHEMICAL PROPERTIES OF ORGANIC COMPOUNDS
DETECTED IN THE SOILS AT CONCENTRATIONS
ABOVE THE ACCEPTABLE SOIL CONCENTRATIONS (1)

Compound	Solubility (ug/l)	Vapor Pressure (mm Hg)
VOLATILE ORGANICS (VOCs):		
Acetone	1,000,000,000	270
Chloroform	8,200,000	151
1,1-Dichloroethane	5,500,000	182
1,1-Dichloroethene	2,250,000	600
Ethylbenzene	152,000	7
Methylene Chloride	20,000,000	362
Methyl Ethyl Ketone	268,000,000	77.5
Methyl Isobutyl Ketone	17,000,000	6
Tetrachloroethene	200,000	17.8
Toluene	535,000	28.1
1,1,1-Trichloroethane	4,400,000	123
1,1,2-Trichloroethane	4,500,000	30
Trichloroethene	1,100,000	57.9
Total Xylenes	198,000	10
BASE NEUTRAL/ACID ORGANICS:		
Bis(2-ethylhexyl)phthalate	1,300	0.0000002
Isophorone	12,000	0.38
Phenol	93,000,000	0.341
PESTICIDES/PCBs:		
Aroclor-1260 (2)	2.7	0.0000405

(1) Acceptable Soil Concentrations are determined in accordance with Footnotes 5, 6, and 7 of Table 3-1.
(2) Soil limit assumed for PCBs is 10,000 ug/kg (40 CFR Part 761.125, "Polychlorinated Biphenyls Spill Cleanup Policy Rule").

REFERENCES:

U.S. EPA, "Superfund Public Health Evaluation Manual," 1986.
U.S. EPA, "Water-Related Environmental Fate of 129 Priority Pollutants," December 1979.

TABLE B10

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Abdul A.S., T.L. Gibson, and D.N. Rai. 1986. "The Eff Organic Carbon on the Adsorption of Fluorene by Materials." Hazardous Waste and Hazardous Materials. V No. 4, pp. 429-440.

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TABLE B10

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U.S. Department of Agriculture, Soil Conservation Service, "Soil Classification - A Comprehensive System." 1960, 7th Approximation.

USEPA, Office of Solid Waste and Emergency Response, "Memorandum on Interim Final Guidance for Soil Ingestion Rates," January 27, 1989.

USEPA, Region V, "Record of Decision for Environmental Conservation and Chemical Corporation, and Northside Sanitary Landfill, Zionsville, Indiana," September 25, 1987.

USEPA, "Draft RCRA Facility Investigation Guidance," July, 1987, OSWER Directive 9502.00-6C.

USEPA, "National Primary Drinking Water Regulations," 40 CFR 141, last amended by 53 FR 37408, September 26, 1988.

USEPA, "Polychlorinated Biphenyls Spill Cleanup Policy Rule," 40 CFR Part 761, published in the Federal Register on April 2, 1987.

USEPA, "Superfund Public Health Evaluation Manual," October, 1986, PB87-183125 with updates of November 16, 1987 and July, 1988.

USEPA, Toxics Integration Branch, OERR, Washington, D.C., December, 1988. "Memorandum with Corrections to the July, 1988 Update of the Risk Characterization Tables in the Superfund Public Health Evaluation Manual."

TABLE B10

REFERENCES

USEPA, "Water-Related Environmental Fate of 129 Priority Pollutants," December, 1979 PB80-204381.

US Geological Survey, "Background Geochemistry of Some Rocks, Soils, Plans, and Vegetables in the Conterminous United States," Professional Paper 574-F, 1975.

Veschueren, K., "Handbook of Environmental Data on Organic Chemicals," 1983.

APPENDIX C

ECC - VAPOR EXTRACTION MODEL

APPENDIX C

ECC - VAPOR EXTRACTION MODEL

This program was written in FORTRAN by Michael C. Marley and George E. Hoag and reported in "Induced Soil Venting for Recovery/Restoration of Gasoline Hydrocarbons in the Vadose Zone," Proceedings, Petroleum Hydrocarbons and Organic Chemicals in Ground Water Conference, Houston, TX, 1984.

The program is based on the concentration of each component in the vapor phase in the soil, using the partial pressure exerted by each compound, as expressed by the following equation:

$$ZT = \frac{VP * X * V * MW}{R * T}$$

where:

ZT = concentration of the component in the vapor phase, mg/l

VP = vapor pressure of compound, mm Hg

X = mole fraction = moles of component/total moles of organics in soil

V = volume of element, liters

MW = molecular weight of component

R = gas constant = 82.4 atm - cm^3/gmoles^{O}K

T = temperature = 294.25^{O}K

The program uses the finite difference method to calculate the change in number of moles of each component during a small time interval (i) and then recalculate over the next time interval (i+1), using the reduced number of moles resulting from subtracting the change in number of moles calculated for interval i from the number of moles present in the soil at the beginning of interval i.

The program runs for a finite length of time or until all the components are removed. The program was rewritten in BASIC and applied to the ECC site.

Table C-1 shows the chemical data used to run the model. The compounds to be evaluated are those shown in Table 3-2, which are amenable to removal by vapor extraction. The maximum detected soil concentrations were taken from Section 4 of the ECC RI, while the vapor pressure and molecular weight data are from USEPA, "Superfund Public Health Evaluation Manual," 1986.

As there was significant variation of compounds concentrations between soil samples at the site, a theoretical block size was chosen. This theoretical soil block is 10 ft x 10 ft x 2 ft deep and was assumed to contain all components of interest at their maximum detected concentrations (Table C-1). Furthermore, it was conservatively assumed that the air flow through the soil would only be 15% efficient in removing the organics. In effect, this represents a worst case estimate of the time required to remove the organics from the soils. The mass of this block was estimated as 10,200 kg.

TABLE C1
CHEMICAL DATA OF COMPOUNDS

Compound (1)	Molecular Weight (2)	Vapor Pressure (2) (mm Hg)	Maximum Detected Soil Concentration (3) (ug/kg)
VOLATILE ORGANICS:			
Acetone	58.1	270	650,000
Chloroform	119	151	2,900
1,1-Dichloroethane	99	182	35,000
1,1-Dichloroethene	97	600	380
Ethylbenzene	106	7	1,500,000
Methylene Chloride	85	362	310,000
Methyl Ethyl Ketone	72.1	77.5	2,800,000
Methyl Isobutyl Ketone	100	6	190,000
Tetrachloroethene	166	17.8	650,000
Toluene	92.1	28.1	2,000,000
1,1,1-Trichloroethane	133	123	1,100,000
1,1,2-Trichloroethane	133	30	550
Trichloroethene	132	57.9	4,800,000
BASE NEUTRAL/ACID ORGANICS:			
Phenol	94.1	0.341	570,000
Isophorone	138	0.38	440,000

(1) Compounds shown are those amenable to soil vapor extraction.
(2) From U.S. EPA, "Superfund Public Health Evaluation Manual," 1986.
(3) From ECC RI, March 1986.

The air flow rate was estimated as a fraction of the total air flow rate to be used at the site (500 SCFM), based on the length of injection trench influencing the assumed soil block (10 ft) as a ratio of the total length of injection trenches (3,800 ft). This represents an air flow rate of 37.26 liters per minute.

The results, summarized in Figure C1, show that essentially no VOCs will be present in the hypothetical soil element after 130 days of soil vapor extraction. To remove phenol and isophorone to the Acceptable Soil Concentrations in Table 3-1, operation of the vapor extraction system for a total of approximately 360 days is necessary.

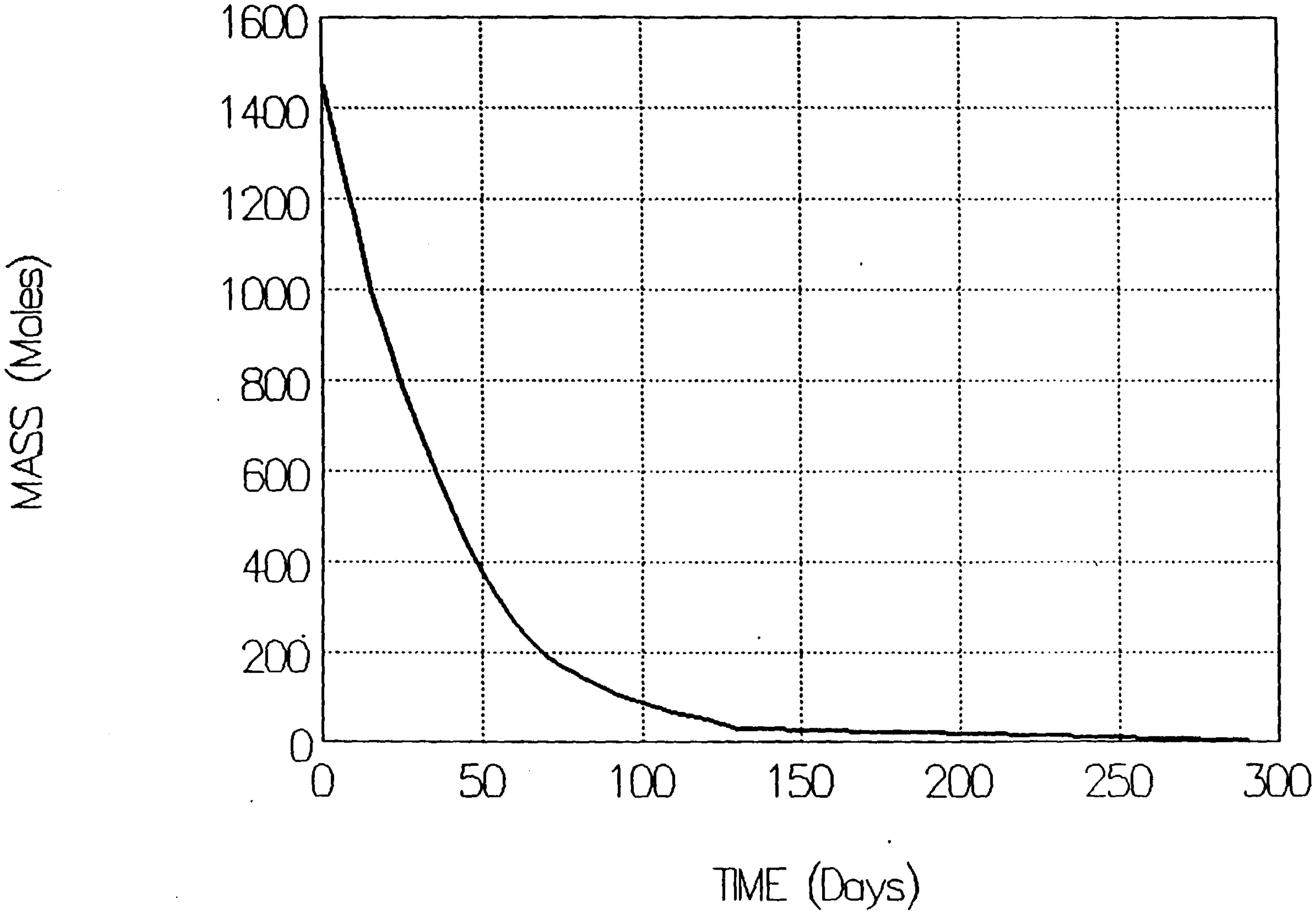
Actual large-scale soil vapor extraction systems have been operated with excellent removals of compounds such as tetrachloroethene, trichloroethene, 1,3-dichloropropene, methyl ethyl ketone, methyl isobutyl ketone, toluene, and xylenes. Some published references are:

- Lisiecki, J.B., and F.C. Payne. "Enhanced Volatilization: Possibilities, Practicalities, and Performance." Presented at the Engineering Foundation Conference, Mercersburg, PA, August 7-12, 1988.

- Regalbuto, D.P., J.A. Barrera and J.B. Lisiecki. "In-Situ Removal of VOCs by Means of Enhanced Volatilization." Proceedings of the Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection, and Restoration, Houston, TX, November 9-11, 1988.

Figure C1

ECC VAPOR EXTRACTION MODEL RESULTS



o Johnson, J.J., and R.J. Sterrett. "Analysis of In-Situ Soil Air Stripping Data." Proceedings of the 5th National Conference on Hazardous Wastes and Hazardous Materials, Las Vegas, Nevada, April 19-21, 1988.

A full-scale vapor extraction system (Lisiecki and Payne, 198 was able to remove tetrachloroethene from 5,600,000 ug/kg to ug/kg, as found by soil sample analysis, in 280 days. Therefor both theoretical models and actual results show that the requir removals will be accomplished by vapor extraction.

APPENDIX D

CALCULATION OF SOIL VAPOR CONCENTRATIONS

APPENDIX D

CALCULATION OF SOIL VAPOR CONCENTRATIONS

The methodology to determine the soil vapor concentrations in equilibrium with Acceptable Soil Concentrations in Table 3-1 is presented below.

The soil vapor concentration of a chemical in equilibrium with the concentration in the soil particles is a function of the soil to water partition coefficient and of the air to water partition coefficient [Lyman, W.J., W.F. Reehl and D.H. Rosenblatt, "Handbook of Chemical Property Estimation Methods," McGraw-Hill, Inc., 1982].

Since not all soil moisture will be evaporated during operation of the vapor extraction system (the soil's hygroscopic water will not be removed by the anticipated operating pressures), a relationship between soil vapor and soil moisture concentrations for the site's soils can be expressed as [Ibid] =

$$C_{sv} = H \cdot C_{sm}$$

where:

C_{sv} = concentration of compound in soil vapor, mg/l

H = Henry's Law Coefficient (nondimensional)

$$= \frac{Vp \cdot MW}{S \cdot R \cdot T}$$

Vp = vapor pressure of compound, mm Hg

MW = molecular weight of the compound, g/gmole

S = solubility of the compound, g/cm^3

R = gas law constant = 62,361 mm Hg - $cm^3/gmole\text{-}^{o}K$

T = soil temperature = 283 ^{o}K

C_{sm} = concentration of compound in soil moisture, mg/l

Similarly, the concentration in soil moisture in equilibrium with the concentration in soil particles can be calculated as [Ibid] =

$$C_{sm} = \frac{C_{sp}}{K_d}$$

where:

C_{sp} = concentration of compound in soil samples, mg/kg

K_d = soil-water partition coefficient, l/kg
[from Appendix B, Table B6]

Combining the two equations, a relationship between soil vapor and soil samples concentration is obtained [Silka, L.R., "Simulation of the Movement of Volatile Organic Vapor Through the Unsaturated Zone as it Pertains to Soil-Gas Surveys," Proceedings of the NWWA/API Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water, 1986, p.204] =

$$C_{sv} = C_{sp} \cdot \frac{H}{K_d}$$

Table D1 presents the data and calculations of the soil vapor concentration in equilibrium with the Acceptable Soil Concentrations in Table 3-1. None of the results shown in Table D1 is above the corresponding vapor saturation concentration, or the concentration in vapor in equilibrium with the pure compound. The vapor saturation concentrations for the compounds in Table D1, assuming each compound is present by itself in the soil vapor (i.e., molar fraction is equal to 1), are shown in Table D2. The vapor saturation concentration is calculated as:

$$C_{sat} = \frac{Vp \cdot X \cdot MW}{R \cdot T} \times 10^6$$

where:

C_{sat} = vapor saturation concentration, mg/l

X = molar fraction of compound in vapor, assumed to be 1

10^6 = factor to convert g/cm^3 to mg/l

TABLE D1 (Page 1 of 2)
SOIL VAPOR CONCENTRATIONS IN EQUILIBRIUM
WITH ACCEPTABLE SOIL CONCENTRATIONS (1)

Compound (2)	Molecular Weight (3) (g/gmole)	Vapor Pressure (3) (mm Hg)	Solubility (3) (ug/l)	Henry's Law Constant (4) (dimensionless)	Soil-water Partition Coefficient (5) (l/kg)	Acceptable Soil Concentration (6) (ug/kg)	Soil Vapor Concentration (7)	
							(mg/l)	ppmv
VOLATILE ORGANICS (VOCs):								
Acetone	58.1	270	1,000,000,000	0.000889	0.00071	490	0.613	254
Chloroform	119	151	8,200,000	0.124	0.116	2,300	2.46	496
1,1-Dichloroethane	99	182	5,500,000	0.186	0.076	5.7	0.014	3.39
1,1-Dichloroethene	97	600	2,250,000	1.47	0.086	120	2.045	515
Ethylbenzene	106	7	152,000	0.277	1.75	234,000	37	9,316
Methylene Chloride	84.9	362	20,000,000	0.0871	0.022	20	0.079	22.4
Methyl Ethyl Ketone	72.1	77.5	268,000,000	0.00118	0.00226	75	0.039	13
Methyl Isobutyl Ketone	100	6	17,000,000	0.00200	0.026	8,900	0.685	233
Tetrachloroethene	166	17.8	200,000	0.837	0.941	130	0.116	16.8
Toluene	92.1	28.1	535,000	0.274	0.607	238,000	107	36,556
1,1,1-Trichloroethane	133	123	4,400,000	0.211	0.183	7,200	8.29	2,819
1,1,2-Trichloroethane	133	30	4,500,000	0.0502	0.183	22	0.0060	1.09
Trichloroethene	132	57.9	1,100,000	0.394	0.242	240	0.39	71.5
Total Xylenes	106	10	198,000	0.303	2.26	195,000	26.2	4,794
BASE NEUTRAL/ACID ORGANICS:								
Phenol	94.1	0.341	93,000,000	0.0000196	0.036	9,800	0.0053	1.36

TABLE D1 (Page 2 of 2)
SOIL VAPOR CONCENTRATIONS IN EQUILIBRIUM
WITH ACCEPTABLE SOIL CONCENTRATIONS (1)

NOTES:

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(1) Acceptable Soil Concentrations are determined in accordance with Footnotes 5 and 6 of Table 3-1.
(2) Compounds above Acceptable Soil Concentrations in Table 3-1 to be removed by vapor extraction.
(3) Data from U.S. EPA, "Superfund Public Health Evaluation Manual," 1986.
(4) Calculated as:

$$\text{Henry's Law Constant (nondimensional)} = \frac{\text{(Vapor Pressure, mm Hg)} * \text{(Molecular Weight, g/gmole)} * \text{(1,000,000 ug/g)} * \text{(1,000 cm3/l)}}{\text{(Solubility, ug/l)} * \text{(R, mm Hg-cm3/gmole-K)} * \text{(T, K)}}$$

where: R = gas law constant = 62,361 mm Hg-cm3/gmole-K; and T = soil temperature = 283 K.

(5) From Appendix B, Table B6.
(6) From Table 3-1.
(7) Calculated as:

$$\text{Concentration in soil vapor (mg/l)} = \frac{\text{(Concentration in soil, ug/kg)} * \text{(Henry's Law Constant, nondimensional)}}{\text{(Partition coefficient, l/kg)} * \text{(1000 ug/mg)}}$$

Concentration in soil vapor (ppmv) = (Concentration in soil vapor, mg/l) * (1000 l/m3) / (Factor, mg/m3/ppmv)

The factors for conversion of mg/m3 to parts per million by volume (ppmv) were obtained from Vershueren, K., "Handbook of Environmental Environmental Data on Organic Chemicals," 2nd Edition, 1983.

TABLE D2
CALCULATION OF VAPOR SATURATION CONCENTRATIONS

Compound (1)	Vapor Pressure (2) (mm Hg)	Molecular Weight (2) (g/gmole)	Vapor Saturation Concentration (3) (mg/l)
VOLATILE ORGANICS (VOCs):			
Acetone	270	58.1	888.9
Chloroform	151	119	1018.2
1,1-Dichloroethane	182	99	1021.0
1,1-Dichloroethene	600	97	3297.8
Ethylbenzene	7	106	42.0
Methylene Chloride	362	84.9	1741.5
Methyl Ethyl Ketone	77.5	72.1	316.6
Methyl Isobutyl Ketone	6	100	34.0
Tetrachloroethene	17.8	166	167.4
Toluene	28.1	92.1	146.6
1,1,1-Trichloroethane	123	133	927.0
1,1,2-Trichloroethane	30	133	226.1
Trichloroethene	57.9	132	433.1
Total Xylenes	10	106	60.1
BASE NEUTRAL/ACID ORGANICS:			
Phenol	0.341	94.1	1.8

(1) Compounds above Acceptable Soil Concentrations in Table 3-1 to be removed by vapor extraction.
(2) Data from U.S. EPA, "Superfund Public Health Evaluation Manual," 1986.
(3) Calculated as:

$$Csat = \frac{Vp * X * MW}{R * T} * 1E{+}06$$

Where: Csat = vapor saturation concentration, mg/l; X = molar fraction of compound in vapor, assumed to be 1; 1E+06 = factor to convert g/cm3 to mg/l; MW = molecular weight of the compound, g/gmole; R = gas law constant, 62,361 mm Hg-cm3/gmole-K; and T = soil temperature, 283 K.